WHOI-93-49

Long Time Series Measurements in the Coastal Ocean: A Workshop

Coastal Ocean Processes

by

C.L. Vincent, T.C. Royer and K.H. Brink

November, 1993

Woods Hole Oceanographic Institution
Woods Hole, MA 02543.

WHOI-93-49

Long Time Series Measurements in the Coastal Ocean: A Workshop

by

C. L. Vincent
Coastal Engineering Research Center
U.S. Army Waterways Experiment Station
Vicksburg, Mississippi
and
Coastal Ocean Program
National Oceanic and Atmospheric Administration
Washington, D.C.

T. C. Royer
Institute of Marine Science
University of Alaska
Fairbanks, Alaska

K. H. Brink
Department of Physical Oceanography
Woods Hole Oceanographic Institution
Woods Hole, Massachusetts

Coastal Ocean Processes (CoOP) Report Number 3

November, 1993

Technical Report

Funding was administered through the National Science Foundation under Grant No. OCE92-24824.

This report should be cited as: Woods Hole Oceanog. Inst. Tech. Rept., WHOI-93-49.
Approved for publication; distribution unlimited.

Approved for Distribution:

James Luyten

James Luyten, Chair
Department of Physical Oceanography

Coastal Ocean Processes (CoOP) Reports

No.

1 *Coastal Ocean Processes (CoOP): Results of an Interdisciplinary Workshop,* 1990, Contribution number 7584 from the Woods Hole Oceanographic Institution, Woods Hole, Massachusetts; 51 pp., by K. H. Brink, J. M. Bane, T. M. Church, C. W. Fairall, G. L. Geernaert, D. S. Gorsline, R. T. Guza, D. E. Hammond, G. A. Knauer, C. S. Martens, J. D. Milliman, C. A. Nittrouer, C. H. Peterson, D. P. Rogers, M. R. Roman, and J. A. Yoder.

2 *Coastal Ocean Processes: A Science Prospectus,* 1992, Woods Hole Oceanographic Institution Technical Report, WHOI-92-18, 88 pp., by K. H. Brink, J. M. Bane, T. M. Church, C. W. Fairall, G. L. Geernaert, D. E. Hammond, S. M. Henrichs, C. S. Martens, C. A. Nittrouer, D. P. Rogers, M. R. Roman, J. D. Roughgarden, R. L. Smith, L. D. Wright, and J. A. Yoder.

3 *Long Time Series Measurements in the Coastal Ocean: A Workshop,* 1993, Woods Hole Oceanographic Institution Technical Report, WHOI-93-49, 101 pp., by C. L. Vincent, T. C. Royer and K. H. Brink.

Executive Summary

Long time series measurements (in excess of 10 years duration) in the coastal ocean are important to science and society. They provide a measure of the health of the coastal ocean and are essential to distinguish long-term trends, caused by anthropogenic effects or climate change for example, from natural variability. They provide a basis for new hypotheses about processes operating in the coastal ocean and a range of conditions for testing predictive capabilities. In addition, they document rare and or catastrophic events that may play a critical role in coastal processes.

Long-term observations are currently made by a variety of Federal, State and other agencies. These programs would benefit from improved coordination, documentation, analysis, and data access. A long-term goal would be to make data available in real time over a network, providing managers as well as researchers access to a diversity of information not available now.

Existing long time series efforts can be readily augmented by addition of existing sensors, enhancing their scope and impact. Significant benefits would result from multidisciplinary measurements to document long-term trends in physical as well as other variables. Standard observations as well as a diversity of approaches and measurements should comprise the suite of long-term measurements.

Sites for long-term observations should be selected to define processes, represent major and diverse oceanographic systems, and to document pristine as well as stressed systems. The initial rationale for sites and observed properties must be clearly defined to avoid monitoring for monitoring's sake. In the long term, three-dimensional zones ("corridors") of long time series measurements might be created.

Long time series measurements should be supplemented with process and modeling studies to ensure appropriate rationale and to provide a regional understanding for the site-specific observations. The Coastal Ocean Processes program (CoOP) might provide some of these studies.

Table of Contents

I Introduction

A. Background

The coastal ocean of the U.S. includes four general regions: the continental shelves and slopes, estuaries and bays, shoreline regions and the Great Lakes. This large and diverse area includes or is bordered by 431 counties in 30 states with nearly 45% of the U.S. population. It is a region of overwhelming economic, ecologic and aesthetic importance to the nation. It is a region of great growth: over 32 million new residents since 1960 and about half the residential and business-related construction of the U.S. The coast is perceived as an area of significant environmental stress and increasing public concern due to mounting pollution problems, habitat loss and degradation, and economic losses due to storms and disappearing fisheries.

This report summarizes a workshop held March 11–12, 1993 in Washington, D.C. to discuss the needs for long time series measurements in the coastal ocean. The workshop was convened as a result of discussions between scientists involved in coastal ocean research and Federal managers responsible for many Federal activities in the coastal ocean. These discussions centered around three main concerns:

- Decisions in the public and private sector that will significantly affect development of the coast will require an assessment of the effect of proposed activities on the coastal ocean. The scientific and managerial communities believe that inadequate baseline data exist from which to draw logical conclusions and to separate anthropogenic effects from natural variability.

- The coastal ocean is a region of high temporal and spatial physical, chemical and biological variability because of its nature as a boundary region between continent, ocean and atmosphere. Consequently, localized or short term measurements can provide misleading indications of the state of the environment or the causes of fluctuations. Long time series are required to unravel and apportion sources of variation and to monitor changes.

- Most of the problems of interest to the nation require knowledge of physical, chemical, geological and biological aspects of this environment. While some data on a few physical factors are available, few long time series data sets are available

where the needed physical, chemical and biological properties have been collected together.

The scientists and managers recognized that solution of the problems of the coastal ocean will require improving the long time series (LTS) data sets available. The working group took as a definition that a LTS would eventually include at least 10 years of data and should eventually include 50–100 years of information or be permanent.

Long time series measurements are an important scientific tool. They can resolve long time scale ($\gtrsim$ 1 year) variability such as El Niño in a way that is impossible for normal, process-oriented studies. At the same time, they can capture rare but energetic events such as floods and hurricanes with confidence, whereas these could only be observed by luck using normal short-term observations. These rare events can dominate some phenomena, such as sediment transport. Long time series are needed in many cases to establish, with statistical confidence, causes of variability, e.g. natural vs. anthropogenic. Long times series can be used to test ideas, generate new hypotheses and drive models.

The usefulness of these data lies far beyond fulfilling scientific curiosity. For example, the evolution of environmental regulation and law has the potential of blocking significant economic development either directly or by requiring uneconomic mitigation actions if the potential impacts cannot be adequately addressed. If the nation is to make reasonable and correct decisions in a region where half our population lives, it must have the background information and concomitant understanding of the coastal ocean, its life forms and processes.

Improving the long-term knowledge base on coastal ocean properties is difficult because:

- Obtaining long time series will require sustained measurement programs over decades,
- The data sets are recognized as valuable when they are are needed, but on a day-to-day basis often appear routine or mundane, hence are often ignored or have low priority for funding,

- The future data needed are most likely to be collected or supported by a variety of agencies or laboratories, not by just one,
- Archiving and data standards required to assure valid information often do not exist and are hard to sustain across agencies over decades,
- In today's scientific environment, short-term, high-pay-off studies attract more interest, and
- For some of the chemical and biological properties, measurement/sampling technology is primitive.

The managers and scientists felt a workshop could provide an improved case for the need and value of long time series data for the nation, could suggest a baseline plan for achieving it, and could encourage federal agencies to act to implement it. The workshop organizers recognized that building the data bases will require a sustained effort, although perhaps at a low profile, over decades and that the path of likely success was to start with adding a few critical measurements to existing operational data collection networks. They recognized however the responsibility of starting now so that future scientists and decision makers would have the data they need.

The workshop was largely motivated by discussion emanating from the CoOP steering committee with NOAA and NSF staff. The following organizations agreed with the desirability of the workshop and provided funding: NOAA, Coastal Ocean Program and the National Ocean Service; Office of Naval Research. Coastal Engineering Research Center, U.S. Army Waterways Experiment Station; National Park Service; Minerals Management Service; and the National Science Foundation. Academic participation was facilitated through the Woods Hole Oceanographic Institution.

B. Workshop Goal and Charge

The goal of the workshop was to establish a practical plan for improving the collection of long time series data for the coastal ocean and to establish a rationale for that plan.

The charges to the workshop participants were:

1. *To rationalize the needs for long time series measurements in the coastal ocean.* The participants were to describe what measurements were needed, with what frequency, where and why. The value of the information to solve scientific and national problems was to be defined, and the role of models in using or interpreting the data needed to be specified.

2. *To describe a practical plan for obtaining the long time series measurements.* The participants were to describe which measurements could be made now and how they could be phased into existing programs. The participants were to consider access to the data and data consistency since the measurements were to be made over decades. Priorities on measurement types and locations were sought.

The participants were asked to consider options that would start with small incremental increases to existing programs: use or expansion of existing platforms was felt to be critical to eventual success fı r such a program.

C. Workshop Participants

The funding agencies and CoOP nominated approximately 65 Federal and academic scientists and managers for invitation, split roughly evenly between academic and Federal participants. An attempt was made to include scientists and managers with backgrounds or needs in the physical, chemical, geological and biological disciplines and to obtain a reasonable geographic spread. Forty-five people actually attended the workshop (Appendix D). The Atlantic and Pacific areas were well represented numerically but the Great Lakes, Gulf of Mexico, Alaska and Hawaii were less so. As a result, the workshop's discussions centered more upon the Atlantic and mainland Pacific seaboards.

D. Workshop Organization

The first morning of the workshop (Appendix E) focussed on uses of existing coastal LTS data sets (which were taken by federal agencies and by state and academic institutions) and a description of major Federal measurement programs. To facilitate discussion, existing federal measurement programs were described by a series of poster presentations. A summary of these ongoing efforts is provided in Appendix A. The

morning session provided examples of the scientific utility and rationalization for long time series measurements (abstracts are provided in Appendix B).

The first afternoon the workshop was split into two working groups: (1) Atlantic and Gulf of Mexico and (2) Pacific and Great Lakes. The working groups addressed the needs, types and uses for long time series measurements for their geographic regime. A plenary session then compared needs by area.

The second morning the same working groups reconvened and, using results from the previous day, discussed practical plans for obtaining LTS data. After lunch the entire workshop met in plenary session to review working group results and to discuss issues related to archiving and data standards. The following sections summarize the working group findings.

II Selection of Coastal Ocean Measurements

The selection of a few key properties to be measured over decades is very difficult because of the size and diversity of the coastal ocean, the complexities of the physical, chemical and biological components of the system, the high spatial and temporal variability of the coastal ocean, and the multiplicity of management and scientific issues and concerns. The first working group sessions were directed at trying to choose a few key measurements and to provide a scientific rationale for their selection.

The consensus of the workshop was that the key properties should be selected based on the following criteria:

- Properties that can be reliably measured now,
- Properties that are likely to be reliable and sensitive indicators of the status of the coastal system, and
- Properties that are likely to be closely related to other system variables, so they can serve as indicators.

Moreover, interest was given to properties that are relatively stable, that is, not likely to vary too rapidly in space or time. Also interest was expressed in those properties that could be quickly and economically added to existing measurement systems. Less emphasis was given to properties that still require research and development activities to make routine measurements. These concerns mirrored the workshop's view that it is better to start making measurements now of those key properties we can observe rather than to delay in order to develop new or improved technologies. New or improved approaches can be added in the future.

The two working groups considered a large number of potential properties. Appendix C provides a summary of the properties discussed, including when and where to measure them, how the data will be used, why the data are needed, and the benefits of obtaining the data. In addition, the logistical support needed and potential new technologies for making the measurements are noted.

Table 1 provides a consolidated list of the key properties from both working groups. The properties denoted with an asterisk are those whose earliest implementation was considered practical. High priority was assigned because of both the high value of the measurement and the ability to make it routinely with present capabilities.

Table 1: Key Properties

Physical oceanographic in-situ series: wind*, temperature*, water level*, river volume fluxes*, ocean currents*, salinity*, upper ocean stratification*

Remotely sensed color* and temperature*

Nutrients*: nitrate, silicate, ammonia, phosphate

Fluorometry* and bioluminescence

Solids (light penetration)

Dissolved gases: carbon dioxide, oxygen

Atmosphere/ocean flux estimates for nutrients and pollutants

Flux estimates of water, chemicals and sediments from land and rivers

Recruitment estimates of important fish species

Species distribution of plankton (especially phytoplankton)

Mammals and seabirds

Benthic conditions: sediment cover, life and chemicals

Metals and contaminants

* Higher priority measurement

III Site Selection

Even knowing which properties to measure, the selection of where they should be measured presents a significant quandary. It was clear to the workshop participants that the variability of the coastal ocean is a significant factor. Specifically, regions with strong gradients, typical of many coastal areas, provide difficulties because very large variations can be caused by mild swings in the location of the gradients. Furthermore, the variations associated with local topography or bathymetry, the proximity of river mouths, etc. can all cause significant local, but not necessarily regional, variation. Clearly, how the coastal ocean changes in response to natural and man-made fluctuations can be of considerable interest locally, but could be so site-specific as not to be indicative of regional patterns. On the other hand, we know that large-scale phenomena, such as El Niño, can be clearly and coherently detected along most of the west coast of North America. This implies that we need not be overly pessimistic about local effects in the coastal ocean dominating important low-frequency variability.

The consensus of the workshop was that although local, site-specific variations are important, primary interest should be directed at those sites where measurements would reveal the health and regional trends of the coastal ocean. Data from such sites would be most likely to show large scale, longer lasting systematic changes and would be helpful in making comparative studies and in understanding the underlying linkages between the physical, chemical, geological and biological components of the coastal system. Careful study of existing measurements will be required to choose sites intelligently. However, the workshop conclusions in no way deny the need for site-specific monitoring because of local interests. Logistical requirements must also be addressed in site selection.

The workshop participants concluded that a comprehensive long time series effort must exploit fixed-site measurements (e.g., moorings), remote sensing and ship-based measurements. Elements of each of these approaches are already in place, through, for example, the NDBC buoy network, existing satellite platforms and fisheries-oriented surveys. These existing systems provide the opportunity to make additional measurements at a relatively modest additional effort.

The underlying concept for making measurements involved the idea of gradually creating "corridors." These corridors would involve making measurements outward

from the beach or an estuary across the shelf and to the slope, and might eventually involve some resolution of alongshore variability. Each would entail several (perhaps three) heavily instrumented moorings and would use ship-based surveys to provide measurements between moorings and in the alongshore direction to assess representativeness and advective processes. Each corridor should be designed to exploit remote sensing as much as possible (for example, try to match satellite altimeter track crossings). In addition, sites should be chosen to maximize potential cooperation and payoff to multiple federal agencies. A representative proposed corridor is that off North Carolina, which would start within Pamlico Sound, include the waters of the Cape Hatteras National Seashore, and extend outward to the Gulf Stream. This effort could thus build on existing efforts involving the NPS, MMS, NOAA and other federal agencies. Corridors could be designated in the near future and be gradually built up from existing measurement systems that fall within their domain. Potential corridor locations are summarized in Table 2.

Due to the uneven regional expertise present at the meeting, and lack of time to catalog agency priorities, actual corridor locations would need further refinement and study.

Table 2: Potential Corridor Sites

Georges Bank
Stellwagen Bank Marine Sanctuary
Narragansett Bay
Middle Atlantic Bight (off New York City)
Chesapeake Bay
South Atlantic Bight (off Pamlico Sound)
Gulf of Mexico (off Corpus Christi and off the Mississippi delta)
Southern California Bight
Monterey Bay Marine Sanctuary
Northern California
Oregon/Washington
Gulf of Alaska shelf (off Seward near Kenai Fjords National Park)
Other Alaska (Bering Sea, Chukchi Sea, Prince William Sound, southeastern Alaska)
Hawaii/Great Lakes

IV Workshop Conclusions

Any workshop process naturally involves limitations due to representation, available time, and so forth. One constraint with this workshop was the uneven distribution of attendees in terms of region, discipline, and phenomena of interest. For example, the Great Lakes and Hawaii were numerically underrepresented as were meteorology, geology and nearshore (surf zone) oceanography. These imbalances are inherently reflected in terms of the specific recommendations made for variables to measure and places to measure them. Inclusion of this added input would only strengthen the case for LTS data and funding requirements, not diminish it.

The following summarize the principal conclusions of the workshop:

- LTS are important. Existing series should be continued and others added. If the nation is to have an adequate data base on the overall health of the coastal ocean, and is to understand anthropogenic versus natural variations, then reliable LTS data are a necessity. For example, without these data, decisions on development and management may, under the existing regulatory and legal environment, either halt development or make it more costly than need be. The potential for significant environmental damage is likewise increased by absence of these data. In either case, the economic consequences are significant.

- LTS are measured by many organizations — a strength and a problem. The data needs of federal and local agencies and the private sector are diverse, and it is unlikely that complete coordination could be achieved. The strength of this is that the data then do not become dependent upon the funding health of any one program. The problem lies in standardization, archiving and coordination.

- Small grants are needed to analyze LTS data sets. Much of the exploration of these data sets requires only small investments and can yield significant dividends. Federal agencies should consider a modest small grants program to promote use of LTS data.

- LTS needs Federal coordination — a potential role for SUSCOS. The Federal government was viewed as having a great interest and need, as well as the long-term stability to monitor such programs. The Subcommittee on U.S. Coastal

Ocean Science (SUSCOS) could take on the role of developing a Federal policy that includes input from the research and user communities.

- We need a good inventory of LTS data sets and how to obtain them. An effort is required to develop an inventory of major LTS data sets and to provide information on how to obtain the data. Many existing long time series, especially those made by local governments or industry, are currently underutilized.

- LTS data sets and sites need to be recognized. A mechanism is needed to promote the visibility, value and need of LTS data and sites so that over the following decades it is clear to funders and users of data that these sites are of special interest and should be continued as a national resource for the future.

- Federal data depositories need to work together on archives and to make LTS data available. The workshop did not expect that one data center would archive all LTS data. Given the flexibility of information networks, it is not clear that this is necessary even if it were desirable. The depositories need to work on common archive standards and indexing. The data should be available on electronic media and through networks.

- The academic community, perhaps through CoOP, could become involved in developing new long time series measurements by initializing some measurements through coordinated federal agency funding. This could involve heavy interdisciplinary sampling of a prototype corridor. All CoOP process studies should exploit existing LTS measurements, where feasible.

- We must develop and promote standards. Standards for data measurement and archives should be developed and promoted so that future users of the data can understand how they were collected and processed. This also minimizes jumps or biases in the data due to inconsistent measurements.

- The key properties listed in Table 1 are a starting set of LTS measurements.

- The sites listed in Table 2 are suggested as the highest priority for a national program, and these should be developed into corridors.

In arriving at these conclusions the workshop participants were driven to develop a practical program that could be implemented with only modest increases in funding

for the immediate future. Inevitably they had to make choices that another group with more time and wider representation might change. The hope is that the suggestions of this workshop will spur agencies that collect LTS data in the coastal ocean to improve the coordination between their programs and move towards collecting consistent, simultaneous co-located data sets on the key properties needed to describe the long term health and status of the coastal ocean.

Much still needs to be done in terms of coordination and implementation for LTS observations in the coastal ocean. Nonetheless, the consensus of the workshop is that that such measurements are valuable, and that incremental enhancements to existing capabilities should start now.

Acknowledgements

All of the workshop attendees contributed to this document, and their role is gratefully acknowledged. Support for the meeting and this document was provided by the Minerals Management Service (MMS), the National Science Foundation (NSF), the National Oceanic and Atmospheric Administration (NOAA, both through the Coastal Ocean Program and the National Ocean Service), the National Park Service (NPS), the Office of Naval Research (ONR), and the U.S. Army Corps of Engineers. Funding was administered through NSF grant OCE92-24824.

Appendix A: Existing Federally-Managed Long Time Series Efforts

A.1: Introduction to Federal Measurement Programs

While coastal long series measurements are currently being made through a number of channels (federal, academic, private, state and local), the federal government is perhaps the most visible source of such data. The following Federal agencies provided poster sessions describing their long time series measurement programs: NOAA National Data Buoy Center; NOAA National Marine Fisheries Service; U.S. Army Corps of Engineers Field Wave Gaging Program; Minerals Management Service; NOAA National Ocean Service, Ocean and Lake Levels Division; NOAA National Ocean Service, Coastal and Estuarine Oceanography Branch; and National Park Service. These poster sessions are reproduced here along with a summary of these programs provided by J. Michael Hemsley, National Data Buoy Center.

Table A.1 summarizes the numbers of data collection sites on a regional basis. The data summary (and maps in Appendix B) suggest that potential LTS data sites counted exceed 600. However, several significant caveats must be emphasized:

- Many of these sites have less than 5 years of data.
- At most of these sites often only one or at most a small number of physical properties are collected. (For example there are a great number of tide stations).
- About 40 sites contain physical, biological, and chemical information and most of those are in the Gulf of Mexico.
- These sites were largely selected for reasons other than monitoring long term health of the coastal ocean, and many of the sites would be useless because the information would be driven by idiosyncrasy of site and the information could not be generalized.

As a result, only a handful of existing sites have the potential of being widely valuable Long Time Series sites.

The programs described in the poster sessions do not cover all Federal measurement sites in the coastal ocean, but do represent the largest number. Likewise, measurements by local and state governments or by the private sector in response to regulatory requirements constitute additional valuable data. Time constraints for the workshop did not allow for these sites to be inventoried.

Table A.1: Long-Term Measurement Sites

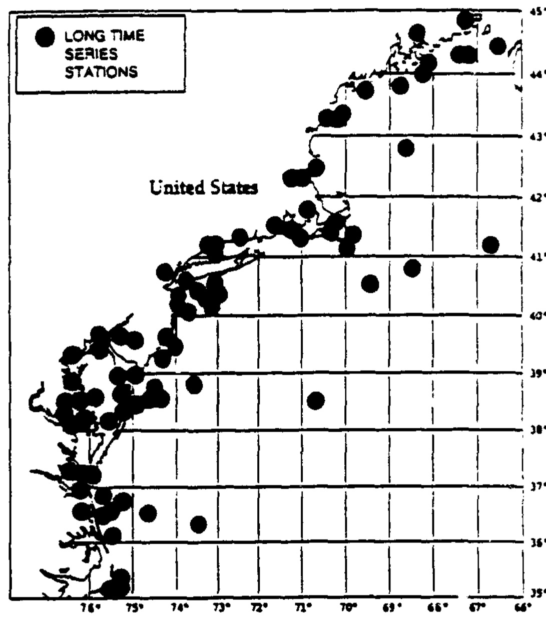
Geographical Region	Existing and Historical Physical	Chemical	Biological
Atlantic: North of Hatteras	123	0	4*
Atlantic: South of Hatteras	49	1	1*
Great Lakes	63	0	0
Gulf of Mexico	143	71	34
Southern California Bight	67	0	1
Northern California	33	1	0
Oregon & Washington	32	0	0
Alaska	38	0	54*
Hawaii	15	0	1
Micronesia	17	0	0

* Also regional surveys

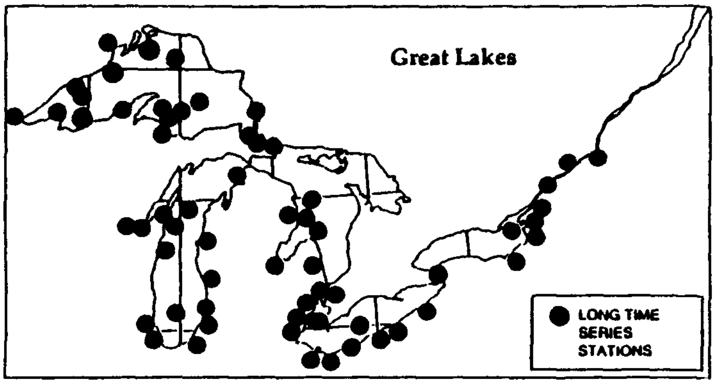
A.2: Summary Plots

All known federally-funded long time series measurement locations are shown in Figures A.1-1 through A.1-3.

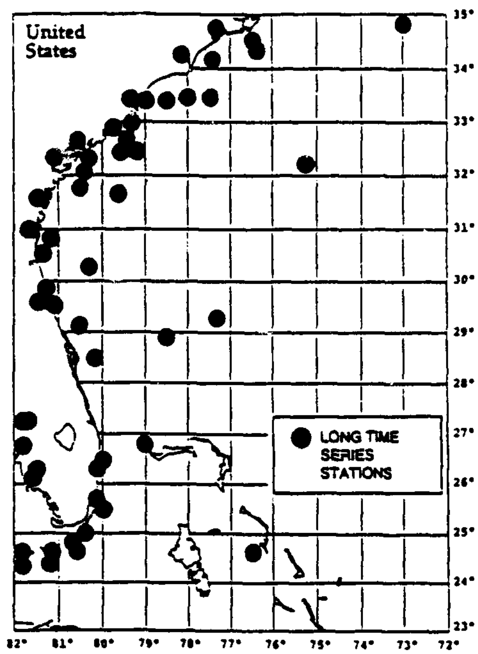
Station Locations, East Coast



Station Locations, Great Lakes



Station Locations, East Coast



Station Locations, Gulf of Mexico

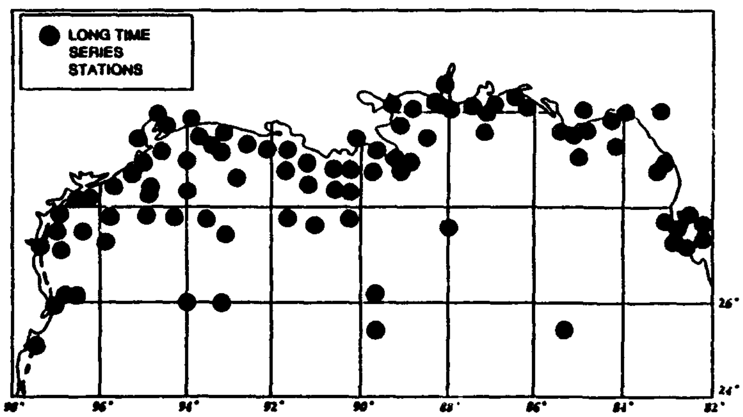
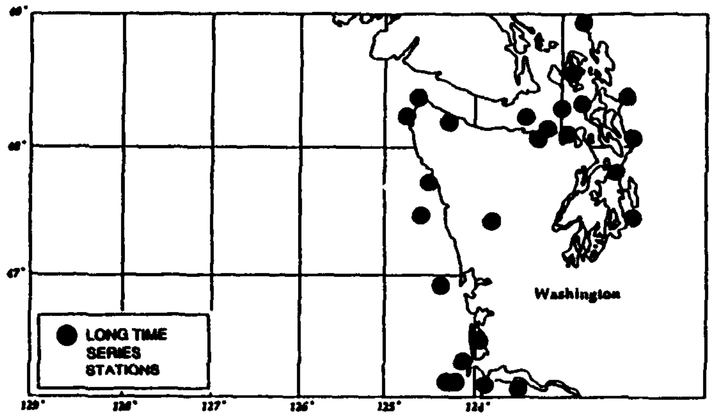
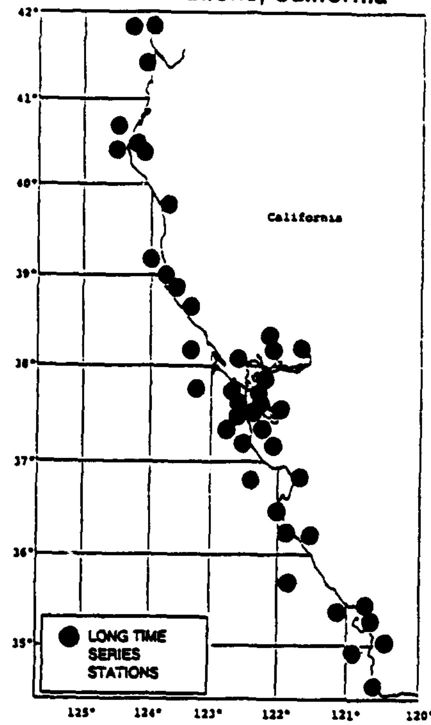


Figure A.1-1

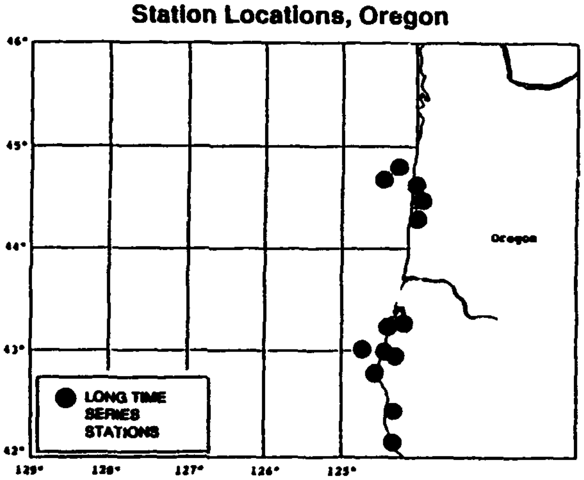
Station Locations, Washington



Station Locations, California



Station Locations, Oregon



Station Locations, California

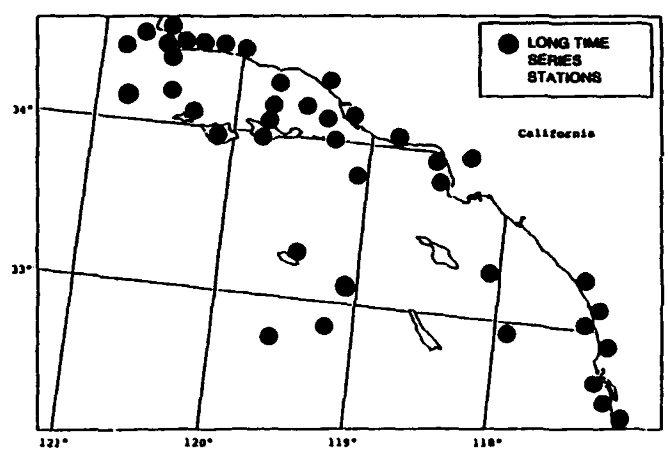
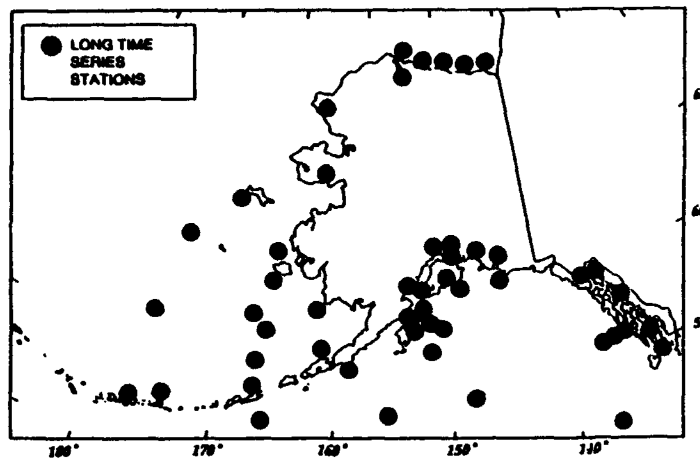
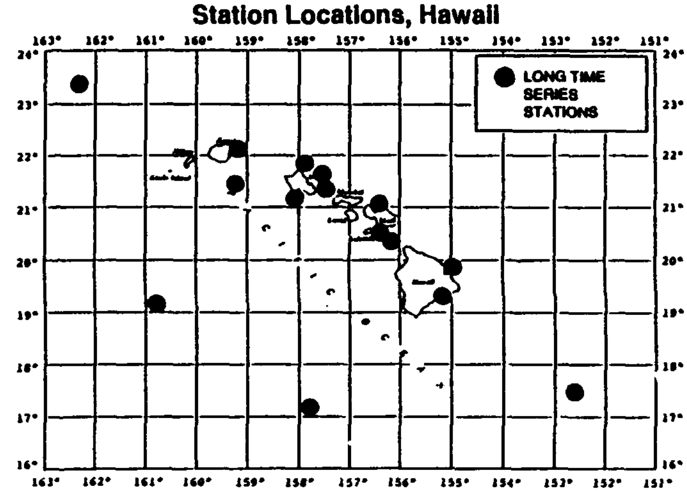


Figure A.1-2

Station Locations, Alaska



Station Locations, Hawaii



Station Locations, Western Pacific

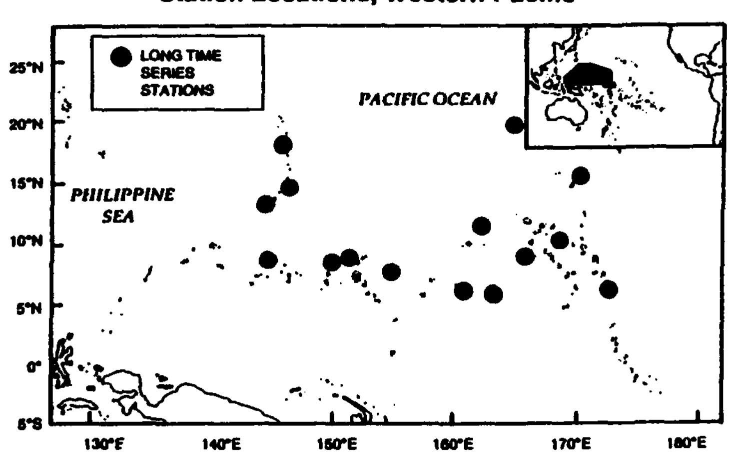


Figure A.1-3

A.3: National Data Buoy Center (NDBC) Station Locations

The history of each station is given in Tables A.2 and A.3 and the locations are shown in Figures A.2. "C-MAN Stations" are automated coastal wind measurement locations.

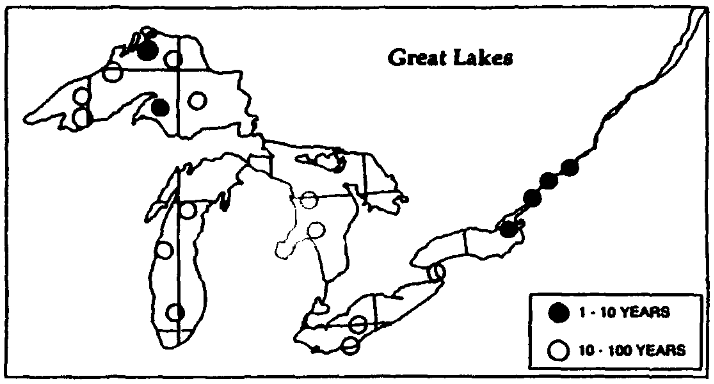
Table A.2-1: U.S. Atlantic Coast

Station ID	Latitude	Longitude	1-10 Years	10-100 Years	Met. Data	Wave Data
C-MAN Stations						
ALSN6	73.8W	40.5N	X		X	X
BUZM3	71.0W	41.4N	X		X	X
CHLV2	75.7W	36.9N	X		X	X
CLKN7	76.5W	34.6N	X		X	
DSLN7	75.3W	35.2N	X		X	X
FBIS1	79.9W	32.7N	X		X	
FPSN7	77.6W	33.5N	X		X	
FWYF1	80.1W	25.6N	X		X	
GLLN6	76.4W	43.9N		X	X	
IOSN3	70.6W	43.0N	X		X	
LKWF1	80.0W	26.6N	X		X	
MDRM1	68.1W	44.0N	X		X	
MISM1	68.9W	43.8N	X		X	
SAUF1	81.3W	29.9N	X		X	
SJLF1	81.4W	30.4N	X		X	
SPGF1	79.0W	26.7N	X		X	
SVLS1	80.7W	31.9N	X		X	X
TPLM2	76.4W	38.9N	X		X	
Moored Buoys						
41001	73.0W	34.9N		X	X	X
41002	75.2W	32.3N		X	X	X
41003	80.4W	30.3N	X		X	X
41004	79.1W	32.5N		X	X	X
41005	79.7W	31.7N	X		X	X
41006	77.4W	29.3N		X	X	X
41008	81.1W	30.7N	X		X	X
41009	80.2W	28.5N	X		X	X
41010	78.5W	28.9N	X		X	X
41016	76.5W	24.6N		X	X	X
44001	73.6W	38.7N		X	X	X
44002	73.0W	40.1N	X		X	
44003	68.5W	40.8N	X		X	X
44004	70.6W	38.5N		X	X	X
44005	68.6W	42.7N		X	X	X
44006	75.5W	36.2N	X		X	X
44007	70.1W	43.5N		X	X	W
44008	69.5W	40.5N		X	X	X
44009	74.6W	38.5N		X	X	X
44011	66.6W	41.1N		X	X	X
44012	74.6W	38.8N		X	X	X
44013	70.8W	42.4N		X	X	X
44014	74.8W	36.6N	X		X	X
44025	73.2W	40.3N	X		X	X
EB 01 (04990)	73.5W	36.4N	X		X	
EB 52 (04992)	74.3W	38.4N	X		X	

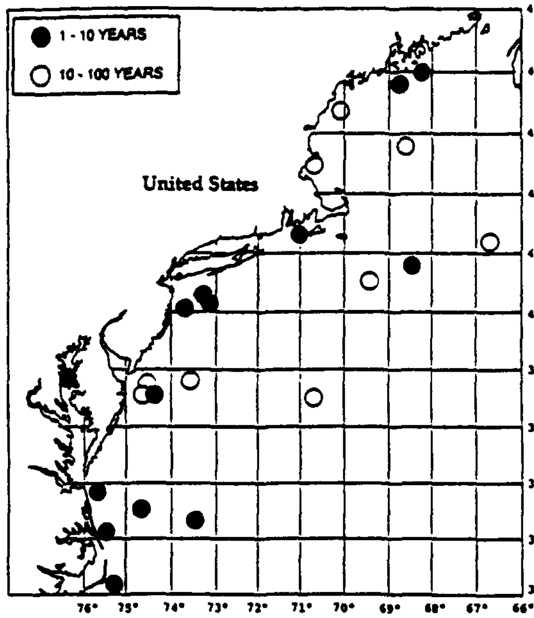
Table A.2-2: North Pacific and Gulf of Alaska

Station ID	Latitude	Longitude	1–10 Years	10–100 Years	Met. Data	Wave Data
C-MAN Stations						
CARO3	124.4W	43.3N	X		X	
DESW1	124.5W	47.7N	X		X	
FFIA2	133.6W	57.3N	X		X	
NWP03	124.1W	44.6N	X		X	
PTAC1	123.7W	39.0N	X		X	
PTGC1	120.7W	34.6N	X		X	
SISW1	122.8W	48.3N	X		X	
TTIW1	124.7W	48.4N	X		X	
WPOW1	122.4W	47.7N	X		X	
Moored Buoys						
46001	148.3W	56.3N		X	X	X
46002	130.4W	42.5N		X	X	X
46003	155.9W	51.9N		X	X	X
46004	135.9W	50.9N		X	X	X
46005	131.0W	46.1N		X	X	X
46006	137.5W	40.9N		X	X	X
46007	152.7W	59.2N	X	X	X	
46008	151.7W	57.1N	X		X	X
46009	146.8W	60.2N	X		X	
46010	124.2W	46.2N		X	X	X
46011	120.9W	34.9N		X	X	X
46012	122.7W	37.4N		X	X	X
46013	123.3W	38.2N		X	X	X
46014	124.0W	39.2N		X	X	X
46016	170.3W	63.3N	X		X	
46017	172.3W	60.3N	X		X	
46018	177.0W	60.3N	X		X	
46019	170.3W	57.2N	X		X	
46020	168.0W	55.9N	X		X	
46022	124.5W	40.8N		X	X	X
46023	120.7W	34.3N		X	X	X
46024	119.2W	32.8N	X		X	X
46025	119.1W	33.7N		X	X	X
46026	122.7W	37.8N		X	X	X
46027	124.4W	41.8N		X	X	X
46028	121.9W	35.8N		X	X	X
46029	124.2W	46.2N		X	X	X
46030	124.5W	40.4N		X	X	X
46035	177.7W	57.0N	X		X	X
46036	133.9W	48.3N	X		X	X
46039	123.4W	48.2N	X		X	X
46040	124.3W	44.8N	X		X	X
46041	124.5W	47.4N	X		X	X
46042	122.4W	36.8N	X		X	X
46045	118.4W	33.8N	X		X	X
46047	119.6W	32.7N	X		X	X
46048	117.9W	32.9N	X		X	X
46050	124.5W	44.6N	X		X	X
46051	120.7W	34.5N	X		X	X
46125	119.1W	33.7N	X		X	X

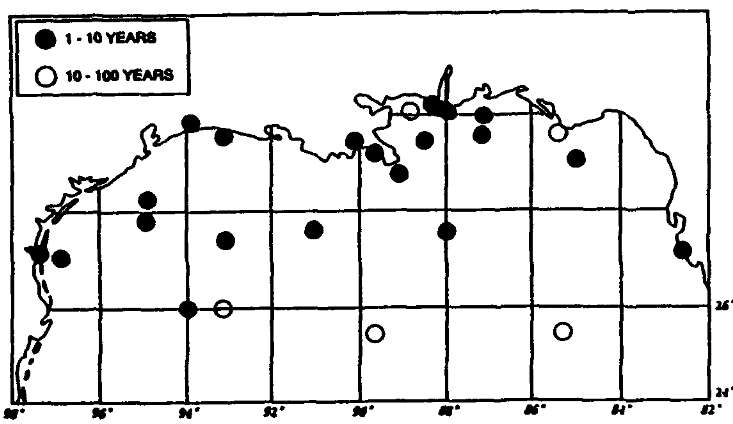
NDBC Station Locations, Great Lakes



NDBC Station Locations, East Coast



NDBC Station Locations, Gulf of Mexico



NDBC Station Locations, East Coast

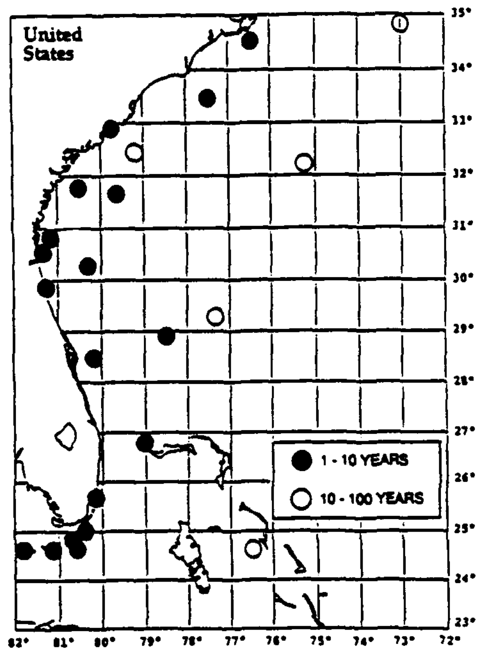
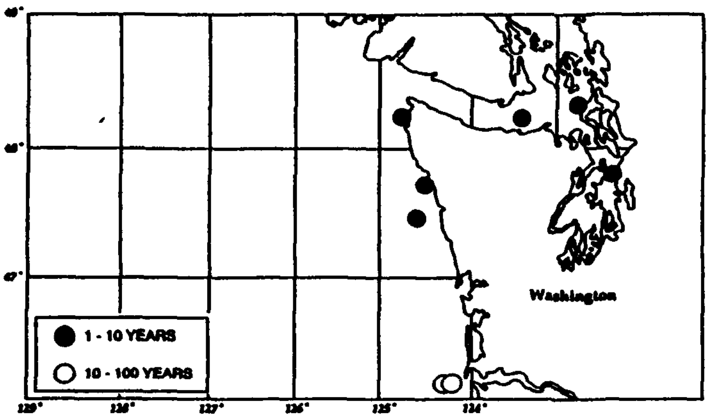
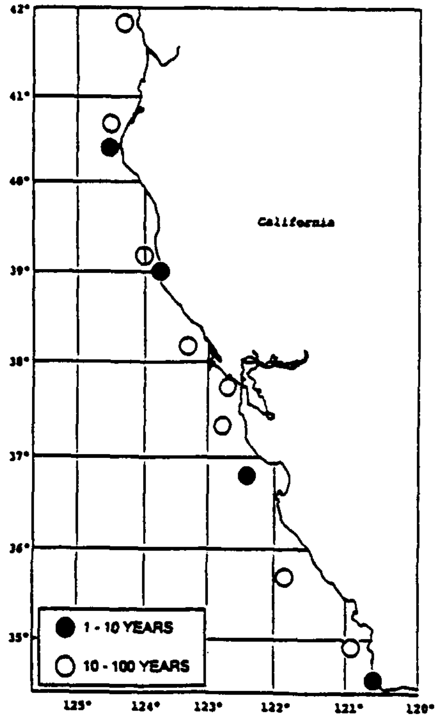


Figure A.2-1

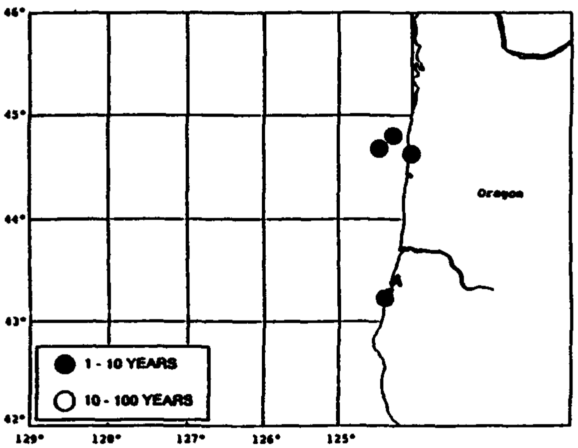
NDBC Station Locations, Washington



NDBC Station Locations, California



NDBC Station Locations, Oregon



NDBC Station Locations, California

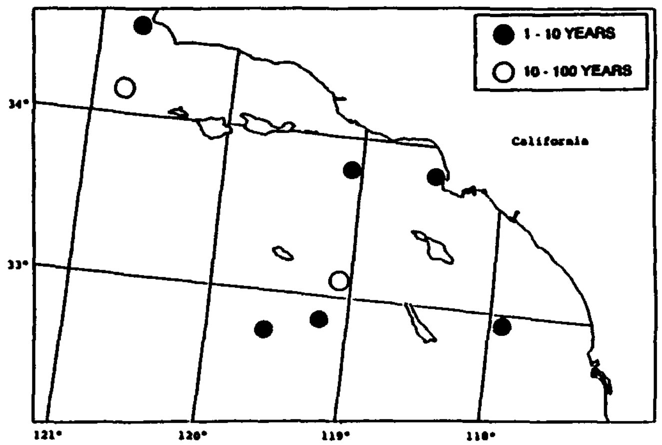
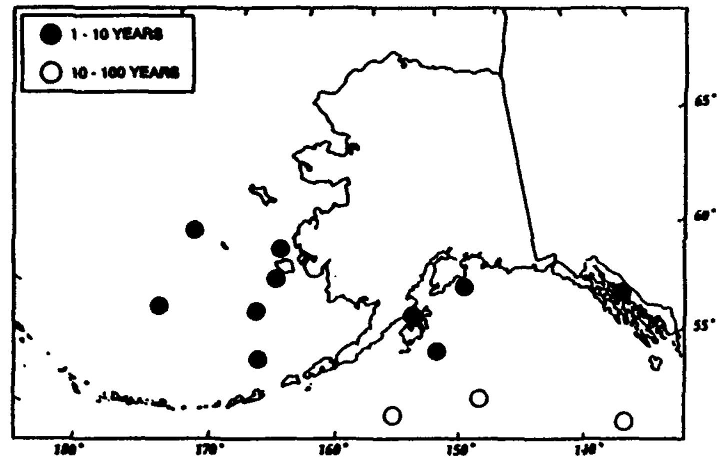
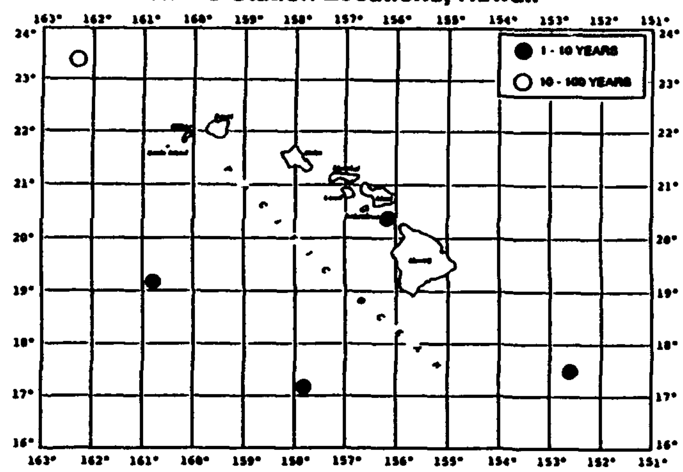


Figure A.2-2

NDBC Station Locations, Alaska



NDBC Station Locations, Hawaii



NDBC Station Locations, Western Pacific - Automated Meteorological Observing Stations (WESTPAC-AMOS)

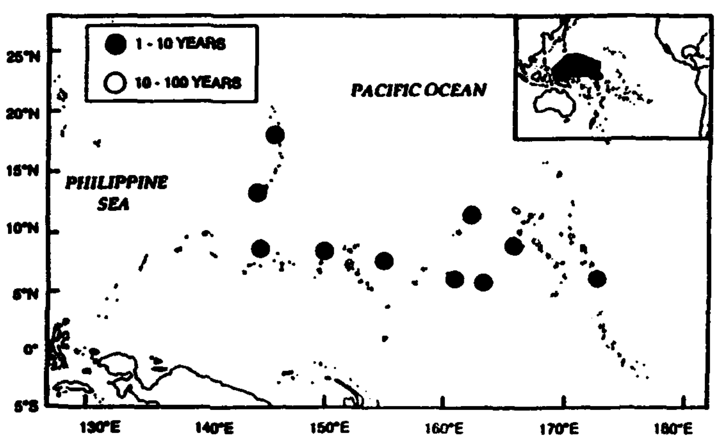


Figure A.2-3

Table A.3-1: Great Lakes

Station ID	Latitude	Longitude	1–10 Years	10–100 Years	Met. Data	Wave Data
C-MAN Stations						
DISW3	90.7W	47.1N		X	X	
DBLN6	79.4W	42.5N		X	X	
PILM4	88.4W	48.2N	X		X	
ROAM4	89.3W	47.9N		X	X	
SBIO1	82.8W	41.6N		X	X	
SGNW3	87.7W	43.8N		X	X	
STDM4	87.2W	47.2N	X		X	
Moored Buoys						
45001	87.8W	48.0N		X	X	X
45002	86.4W	45.3N		X	X	X
45003	82.7W	45.3N		X	X	X
45004	86.5W	46.5N		X	X	X
45005	82.4W	41.7N		X	X	X
45006	89.9W	47.3N		X	X	X
45007	87.1W	42.8N		X	X	X
45008	82.4W	44.3N		X	X	X

Table A.3-2: Pacific Islands

Station ID	Latitude	Longitude	1–10 Years	10–100 Years	Met. Data	Wave Data
C-MAN Stations						
91222	145.8E	181.N	X		X	
91251	162.4E	11.4N	X		X	
91328	149.7E	8.6N	X		X	
91343	155.1E	7.4N	X		X	
91353	160.7E	6.2N	X		X	
91355	163.0E	5.4N	X		X	
91365	165.7E	8.9N	X		X	
91377	172.6E	6.1N	X		X	
FARP2	144.6E	8.6N	X		X	
Moored Buoys						
51001	162.3W	23.4N		X	X	X
51002	157.8W	172.N	X		X	X
51003	160.8W	19.2N	X		X	X
51004	152.6W	17.5N	X		X	X
51005	156.1W	20.4N	X		X	X
52009	144.5E	13.2N	X		X	X
32301	105.2W	9.9S		X	X	X
32302	85.1W	18.0S	X		X	X

Table A.3-3: Gulf of Mexico

Station ID	Latitude	Longitude	1–10 Years	10–100 Years	Met. Data	Wave Data
C-MAN Stations						
ALRF1	80.6W	24.9N	X		X	
BURL1	89.4W	28.9N	X		X	
BUSL1	90.9W	27.9N	X		X	
CSBF1	85.4W	29.7N		X	X	
DPIA1	88.1W	30.3N	X		X	
GBCL1	93.1W	27.8N	X		X	X
GDIL1	90.0W	29.3N	X		X	
LNEL1	89.1W	28.2N	X		X	X
MLRF1	80.4W	25.0N	X		X	X
MPCL1	88.6W	29.4N	X		X	X
PTAT2	97.1W	27.8N	X		X	
SANF1	81.9W	24.5N	X		X	
SMKF1	81.1W	24.6N	X		X	
SRST2	94.1W	29.7N	X		X	
VENF1	82.5W	27.1N	X		X	
Moored Buoys						
42001	89.7W	25.9N		X	X	X
42002	93.5W	26.0N		X	X	X
42003	85.9W	25.9N		X	X	X
42005	85.9W	30.0N	X		X	
42007	88.8 W	30.1N		X	X	X
42008	95.3W	28.7N	X		X	
42009	87.5W	29.3N	X		X	X
42011	93.5W	29.6N	X		X	
42015	88.2W	30.2N	X		X	X
42016	88.1W	30.2N	X		X	X
42019	95.0W	27.9N	X		X	X
42020	96.5W	27.0N	X		X	X
42025	80.4W	24.9N	X			X
EB-10 (02990)	88.0W	27.5N	X		X	X
EB-12 (02998)	94.0W	26.0N	X		X	
EB-62 (02999)	85.6W	29.0N	X		X	

A.4: NOAA/National Marine Fisheries Service — Examples of Living Marine Resource Long Time Series Databases

Northeast Region:

New England Groundfish: Changes in species composition (1963–90).
Northeast Ground Resource Abundance Indices (1963–91).
Landings of Principal Groundfish: Northeast USA (1960–92).

Southeast Region:

Gulf of Mexico Shrimp Recruitment and Landings (1960–90).
Atlantic Menhaden: Harvest, Effort, and Catch by Area (1960–90).

Alaska/Northwest Region:

Northern Fur Seal: Abundance of Pups and Adult Males (1911–91).

Southwest Region (CalCOFI data sets):

California Halibut Landings and Larval Abundance (1950–82).
California Current: Temperature and Zooplankton Abundance (1951–84).

Other:

Atlantic and Gulf Harvest of Sea Scallops and Bay Scallops (1950–91).
Total U.S. Salmon Landings (1930–90).
Chesapeake Bay: Total Finfish and Shellfish Landings (1880–1991).

A.5: U.S. Army Corps of Engineers — Field Wave Gaging Program

The U.S. Army Corps of Engineers wave measurements program is described in Tables A.4 and A.5, and the station locations are shown in Figure A.3.

Table A.4

FIELD WAVE GAGING PROGRAM
ACTIVE GAGES for FY 93

Gage	Location	Latitude	Longitude
NDBC			
41004	South Carolina Bight	32 30.6'N	79 6.0'W
41009	Canaveral, FL	28 30.0'N	80 11.0'W
42001	Central Gulf of Mexico	25 55.7'N	89 39.2'W
42002	Western Gulf of Mexico	25 55.5'N	93 35.2'W
42003	Eastern Gulf of Mexico	25 56.2'N	85 54.9'W
44009	Delaware Bay Entrance	38 25.5'N	74 39.0'W
44013	Boston, MA	42 24.0'N	70 48.0'W
44014	Norfolk, VA	36 34.9'N	74 50.0'W
44025	Long Island, NY	40 15.0'N	73 10.0'W
45005	Lake Erie, MI	41 40.6'N	82 23.9'W
45007	South Lake Michigan	42 45.0'N	87 04.0'W
46025	Catalina Ridge, CA	33 44.8'N	119 04.1'W
46030	Blunts Reef, CA	40 26.4'N	124 29.4'W
46042	Monterey Bay, CA	36 45.0'N	122 24.5'W
46045	Redondo Beach, CA	33 50.3'N	118 26.8'W
46050	Yaquina, OR	44 36.7'N	124 30.8'W
46051	Harvest Platform, CA	34 28.5'N	120 41.2'W
51026	Molokai, HI	21 21.5'N	156 58.0'W
52009	Guam	13 43.4'N	144 42.7'E
PMAB			
	Chicago, IL	41 55.2'N	87 34.2'W
	Long Branch, NJ	40 58.2'N	73 58.2'W
	Dewey Beach, DE	38 42.0'N	75 03.6'W
	Ocean City, MD	38 24.0'N	75 02.4'W
	Virginia Beach, VA	36 51.0'N	75 58.2'W
	Kahului, HI	20 54.7'N	156 28.4'W
SIO			
	Pearl Harbor, HI	21 18.0'N	157 57.2'W
	Makapuu Point, HI	21 18.6'N	157 34.2'W
	Imperial Beach, CA	32 35.0'N	117 08.2'W
	Mission Bay, CA	32 44.8'N	117 22.3'W
	Scripps Pier, CA	32 52.0'N	117 15.4'W
	Oceanside Pier, CA	33 11.4'N	117 23.4'W
	San Nicolas Island, CA	33 14.3'N	119 50.6'W
	San Nicolas, CA (Barge Landing)	33 16.0'N	119 26.8'W
	San Clemente, CA	33 24.9'N	117 37.8'W

Field Wave Gaging Program, page 2 **Table A.4** (continued)

Location	Latitude	Longitude
SIO, continued		
Huntington Beach, CA	33 35.0'N	118 00.0'W
Harvest Platform, CA	34 28.2'N	120 40.9'W
Diablo Canyon, CA	35 12.5'N	120 51.7'W
Marina, CA	36 42.0'N	121 48.9'W
Santa Cruz, CA	36 57.2'N	122 00.2'W
Farallon Islands, CA	37 30.3'N	122 52.4'W
Coquille River, OR	43 07.4'N	124 26.4'W
Coquille River, OR	43 06.7'N	124 30.0'W
Long Beach, WA	46 23.5'N	124 04.7'W
Gray's Harbor, WA	46 51.5'N	124 15.7'W

Table A.5

Funded By	Index No.	Area Name	Installed	Fiscal Year 92	93	94	95	96	Oper. By
		South Atlantic Division (Continued)							
FWGP/NASA	E53	Cape Canaveral	93		///				NDBC
FWGP/NWS	G29	Eastern Gulf	76	0000	////	////	////	////	NDBC
FWGP	E43	South Carolina Bight	92	//	////	////	////	////	NDBC
FWGP/SC	E42	Folley Island					X	XXXX	NEMO
FWGP	G4	Tampa Offshore						//	NDBC
FWGP	G34	San Juan						X	NEMO
		Southwest Division							
MCCP/FWGP	G22	Matagorda	92	##	XXX	XXXX	XXXX		NEMO
FWGP/NWS	G27	Western Gulf				////	////	////	NDBC
FWGP	G27	Brownsville					XXXX	XXXX	NEMO
		South Pacific Division							
FWGP/CA	W1-A	San Diego Scripps Pier	76	****	****	****	****	****	SIO
FWGP/CA		Mission Bay	78	0000	0000				SIO
FWGP/CA		Imperial Beach	83	XXXX	XXXX	XXXX	XXXX	XXXX	SIO
USN/FWGP		San Diego Harbor Ent.	93		XXX	X			SIO
SPL/FWGP	W1-B	Oceanside	76	XXXX	X				SIO
FWGP/CA		San Clemente	83	XXXX	XXXX	XXXX			SIO
FWGP	W2[2]	Catalina Ridge	82	////	////				NDBC
FWGP/USN	W4	Southern Calif. Bight	91	////	////	////	////	////	SIO
CoR&D/FWGP	W9	Point Arguello	87	****	XXXX	XXXX	XXXX	XXXX	SIO
FWGP[3]			92	/	////				NDBC
FWGP			92	/	////				SIO
FWGP	W11	Morrow Bay	83	0000					SIO
SPF/FWGP	W14	Monterey Bay	77	XXXX	XX				SIO
FWGP			86	XXXX	X				SIO

[2] Assumes continued support through congressional ad-on $

[3] NDBC 3 m buoy temporarily placed at Harvest Platform for comparison w/large baseline slope array.

Table A.5 (continued)

Funded By	Index No.	Area Name	Installed	Fiscal Year 92	93	94	95	96	Oper. By
		North Central Division							
FWGP/NWS	L26	Western Lake Erie	89	/- //*	/-//	/-//	/-//	/-//	NDBC
FWGP/NWS	L15	Southern Lake Michigan	90	/-//	/-//	/-//	/-//	/-//	NDBC
NCC/FWGP	L12	Chicago	90	XXXX	XXXX				NEMO
MCCP/FWGP	L14	St. Joseph Harbor	93		X	XXXX			NEMO
		New England Division							
FWGP/NWS	E5[1]	Boston[1]					////	////	NDBC
		North Atlantic Division							
NAP/FWGP	E26	Rehoboth Beach	92		XXXX	XXXX	XXXX		NEMO
EEv/NAB	E27	Ocean City	88	XXXX	XXXX				NEMO
			88	XXXX	XXXX				NEMO
FWGP	E30	Norfolk Canyon	90	////	////	////	////	////	NDBC
FWGP/VA	E32	Virginia Beach	90	XXXX	XXXX	XXXX			NEMO
NAN/FWGP	E19	Ambrose	91	////	////	////	////	////	NDBC
NAN/FWGP	E20	Long Branch	92	XXXX	XXXX	XXXX	XXXX	XXXX	NEMO
CoR&D		Duck	86	XXXX	XXXX	XXXX	XXXX	XXXX	FRF
FWGP/VA	E31	Chesapeake Bay Entrance			XX	XXXX	XXXX	XXXX	VIMS
		Lower Mississippi Valley Division							
FWGP	G14	Grand Isle				XXXX	XXXX	XXXX	NEMO
FWGP/NWS	G28	Central Gulf 42A01	92	/	////	////	////	////	NDBC
		South Atlantic Division							
USN	E47	St. Marys Entrance	88	//					NDBC
USN	G8	Pensacola	89	####	####	####	####	####	UF
FWGP/FL	E58	Miami	93		##	####	####	####	UF
FWGP/FL	E52	Port Canaveral	93		##	#			UF
FWGP/SHOALS	G3	Sarasota	93		XX	XXXX	XXXX	XX	NEMO

*Note (-) denotes gage withdrawn this quarter
[1]Contingent on decision by NDBC to replace USCG large navigation buoys with 3-m discus buoys.

Table A.5 (continued)

Funded By	Index No.	Area Name	Installed	Fiscal Year 92	93	94	95	96	Oper. By
		<u>South Pacific Division (Continued)</u>							
FWGP	W15	Monterey Offshore	87	////	////	////	////	////	NDBC
FWGP/CA	W17	Montara	86	XXX					SIO
FWGP/CA	W18	Farallon Islands	82	0000	0000				SIO
CoCA/FWGP	W3-C	Newport Beach	92	XX	XXX	XXXX	XXXX	XXXX	SIO
FWGP	W23	Blunts Reef	84		////	////	////	////	NDBC
MCCP/FWGP	W3-B	Redondo	91		////	////			NDBC
MCCP			93		XXXX	XXXX			NEMO
LA/LB	W3-A	San Pedro Bay	86	####	####				NEMO
MMS	W1-C	San Pedro Channel	91	/	////	////	////	////	NDBC
			91	/	////	////			NDBC
		<u>North Pacific Division</u>							
FWGP/WA	W41	Grays Harbor	81	0000	00//	////	////	////	SIO
MCCP	W35	Yaquina	91	////	////	////	////	////	NDBC
FWGP	W31	Coquille	81	0000	0000				SIO
FWGP			83	XXXX	XXXX	XXXX	XXXX	XXXX	SIO
FWGP	W37	Columbia River Entrance	83	XXXX	XXXX	XXXX	XXXX	XXXX	SIO
		<u>Pacific Ocean Division</u>							
FWGP	P13	Oahu NE (Makapu)	81	0000	0000				SIO
USN/FWGP	P14	Honolulu	93		XXX				SIO
MCCP/FWGP	P22	Guam W	90	////	////	////			NDBC
HI	P10	Kahului Harbor			X	XX			NEMO
FWGP	P11	Maui Offshore, North	93		///	////	////	////	NDBC
HI	P7	Kawaihie				XX	XXXX	XX	NEMO

Table A.5 (contined): List of Symbols

Gage Types

@	DWG-CM (directional + currents)
#	Puv gage (directional + currents)
%	Anemometer
*	Single pressure gage (nondirectional)
+	Linear array (directional)
X	Sxy or DWG-1 (directional)
0	Nondirectional buoy wave gage
/	Directional buoy wave gage

Table A.5 (continued): **List of Abbreviations**

CA	State of California
CoCA	Coast of California Storm and Tidal Wave Study
CoR&D	Coastal Engineering Research and Development Programs
EEv	Episodic Events Work Unit
FL	State of Florida
FRF	Field Research Facility
FWGP	Field Wave Gaging Program
HI	Hawaii
LA/LB	Los Angeles/Long Beach Harbors Model Enhancement Program
MCCP	Monitoring Completed Coastal Projects Program
MMS	Minerals Management Service
NAB	U.S. Army Engineer District, Baltimore
NAN	U.S. Army Engineer District, New York
NAP	U.S. Army Engineer District, Philadelphia
NASA	National Aeronautics and Space Administration
NCC	U.S. Army Engineer District, Chicago
NDBC	National Data Buoy Center
NEMO	Network for Engineering Monitoring of the Ocean
NWS	National Weather Service
SHOALS	Scanning Hydrographic Operational Airborne Lidar Survey
SIO	Scripps Institution of Oceanography
SPF	U.S. Army Engineer District, San Francisco
SPL	U.S. Army Engineer District, Los Angeles
UF	University of Florida
USN	United States Navy
VA	State of Virginia
VIMS	Virginia Institute of Marine Sciences
WA	State of Washington

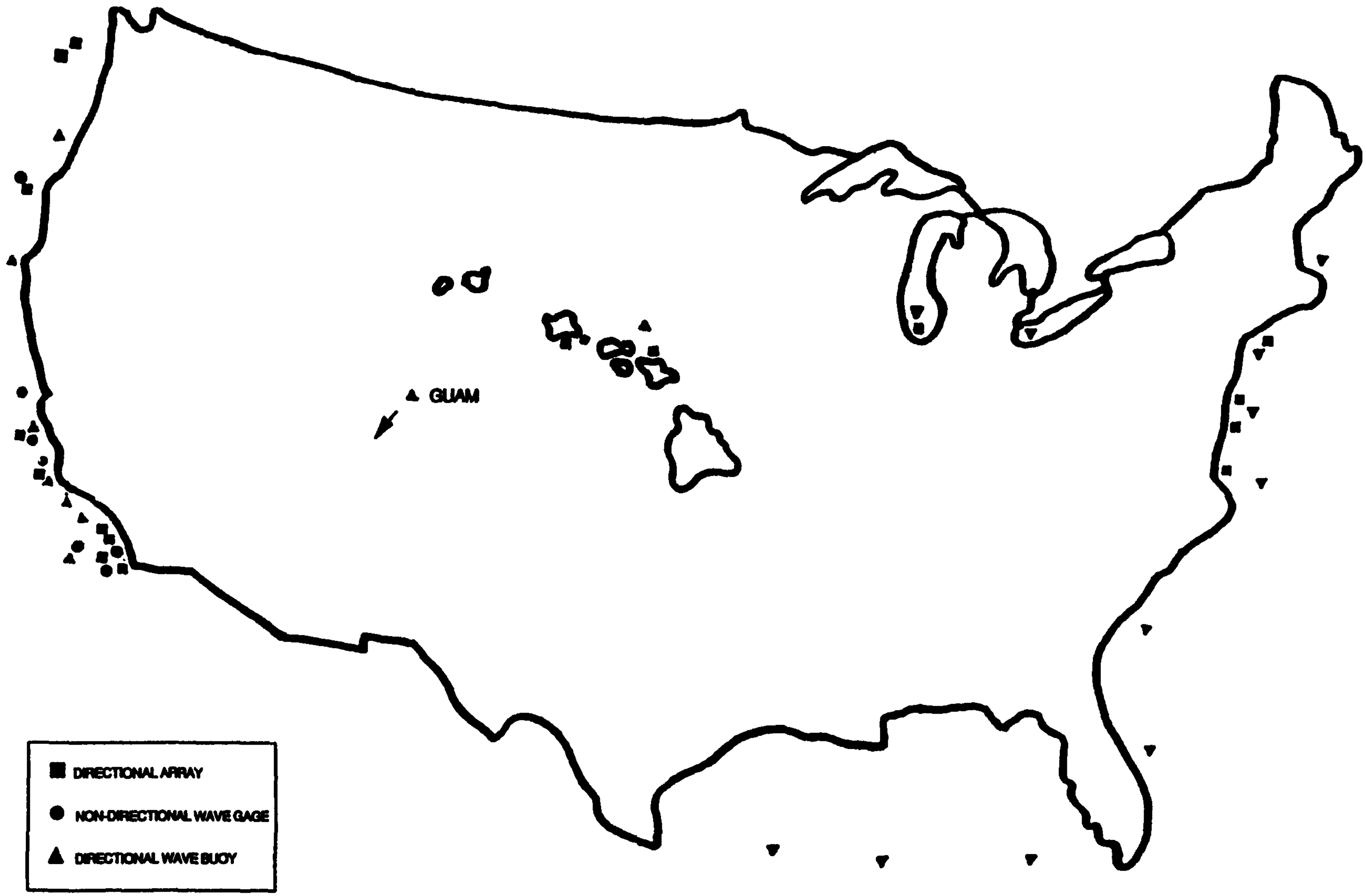

GUAM
DIRECTIONAL ARRAY
NON-DIRECTIONAL WAVE GAGE
DIRECTIONAL WAVE BUOY

Figure A.3

A.6: Minerals Management Service (MMS)

Minerals Management Service has funded Long Time Series observations of meteorology (through NDBC) and of marine mammals and reptiles. Minerals Management Service study areas are defined in Figure A.4.

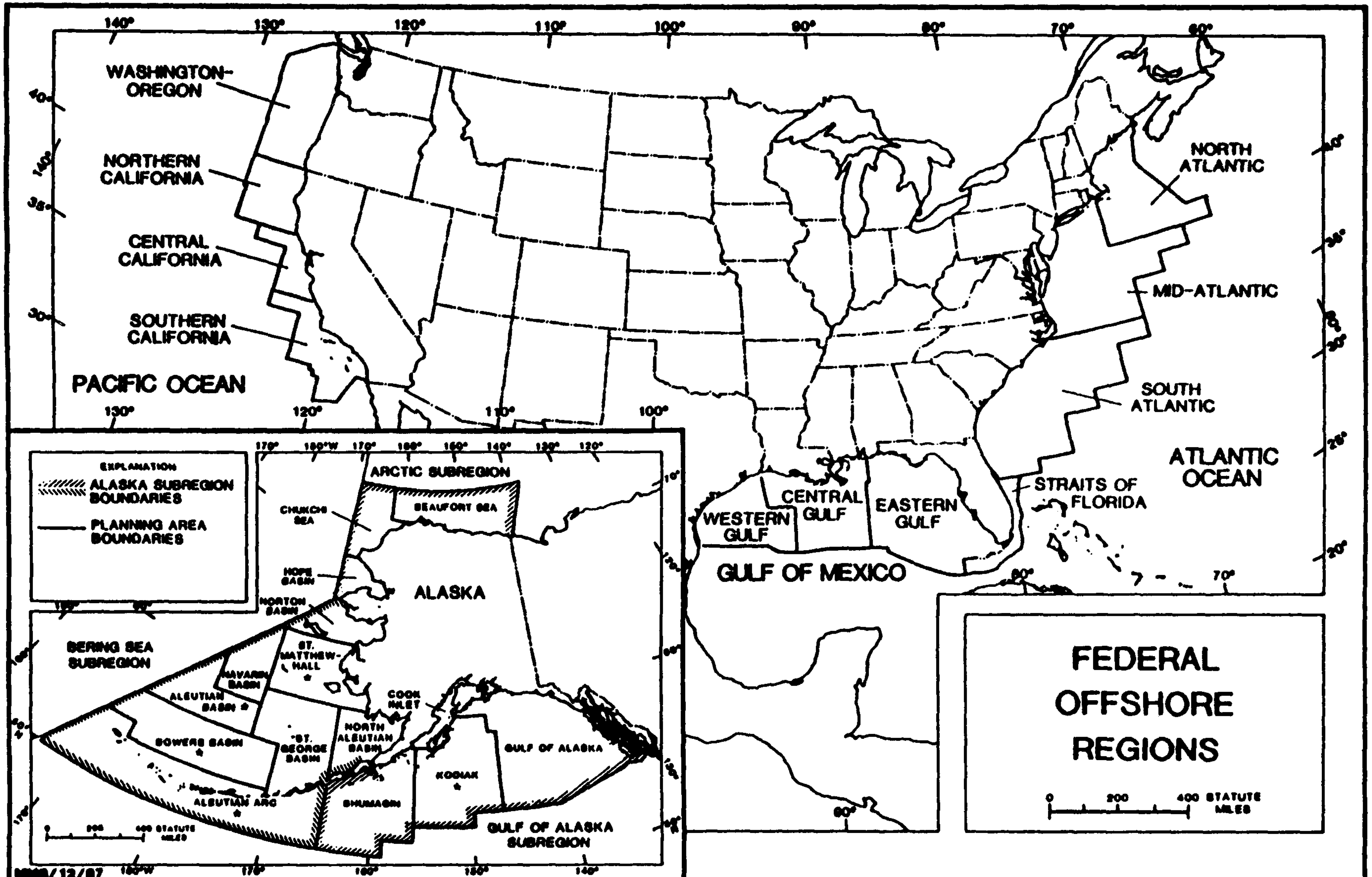

WASHINGTON-OREGON
NORTHERN CALIFORNIA
CENTRAL CALIFORNIA
SOUTHERN CALIFORNIA
PACIFIC OCEAN
NORTH ATLANTIC
MID-ATLANTIC
SOUTH ATLANTIC
ATLANTIC OCEAN
STRAITS OF FLORIDA
WESTERN GULF
CENTRAL GULF
EASTERN GULF
GULF OF MEXICO
FEDERAL OFFSHORE REGIONS
0 200 400 STATUTE MILES
EXPLANATION
ALASKA SUBREGION BOUNDARIES
PLANNING AREA BOUNDARIES
ARCTIC SUBREGION
BEAUFORT SEA
CHUKCHI SEA
HOPE BASIN
NORTON BASIN
ALASKA
BERING SEA SUBREGION
NAVARIN BASIN
ST. MATTHEW-HALL
ALEUTIAN BASIN
COOK INLET
ST. GEORGE BASIN
NORTH ALEUTIAN BASIN
BOWERS BASIN
ALEUTIAN ARC
SHUMAGIN
KODIAK
GULF OF ALASKA
GULF OF ALASKA SUBREGION
MMS/12/87

Figure A.4

A.7: NOAA National Ocean Service

The National Ocean Service carries out routine measurements of coastal sea level (Figure A.5 is a sample, showing starting dates of different measurements) and more recently of harbor currents (Table A.6, Figure A.6).

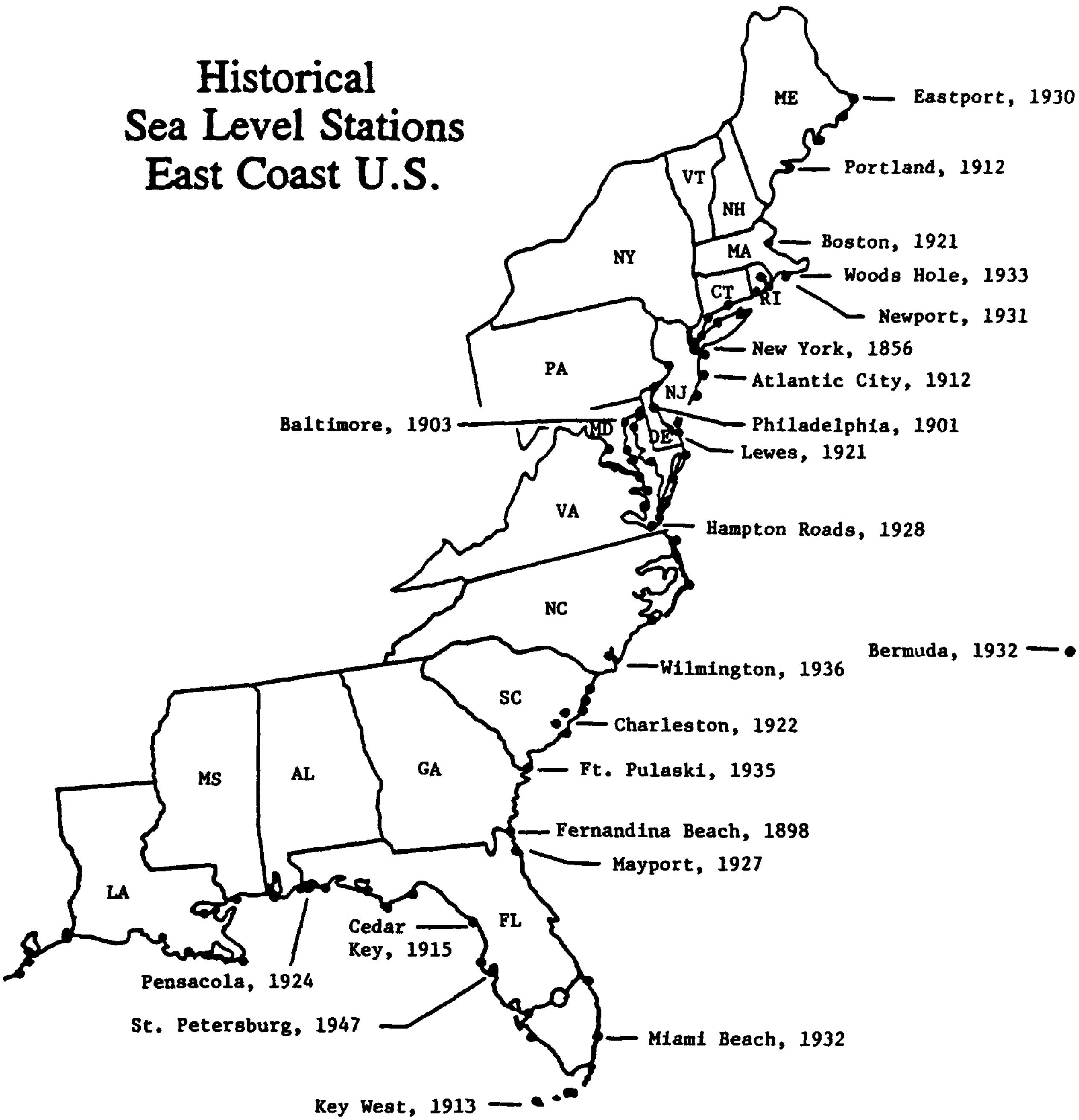

Historical
Sea Level Stations
East Coast U.S.
ME
Eastport, 1930
VT
NH
Portland, 1912
NY
MA
Boston, 1921
Woods Hole, 1933
CT
RI
Newport, 1931
PA
New York, 1856
Atlantic City, 1912
NJ
Baltimore, 1903
MD
DE
Philadelphia, 1901
Lewes, 1921
VA
Hampton Roads, 1928
NC
Bermuda, 1932
Wilmington, 1936
SC
Charleston, 1922
MS
AL
GA
Ft. Pulaski, 1935
Fernandina Beach, 1898
Mayport, 1927
LA
Cedar Key, 1915
FL
Pensacola, 1924
St. Petersburg, 1947
Miami Beach, 1932
Key West, 1913

Figure A.5

Table A.6

Office of Ocean and Earth Sciences
National Ocean Service
National Oceanic and Atmospheric Administration

Tampa Bay PORTS (Physical Oceanographic Real-Time System)

Fact Sheet

- Physical oceanographic real-time system (PORTS) is an information acquisition and dissemination technology developed by the National Ocean Service (NOS). The first permanent, fully-integrated, operational PORTS was deployed in Tampa Bay during 1990 and 1991. The system is managed, operated, and maintained by the Mote Marine Laboratory under a cooperative agreement with NOS.

- The Tampa Bay PORTS includes the integration of real-time current, water level, wind, and water temperature measurements at multiple locations with a data dissemination system that includes telephone voice response as well as modem dial-up.

- PORTS provides essential information for safe and cost effective navigation, search and rescue, hazardous material and oil spill prevention and response, and scientific research. PORTS also provides NOAA's Global Ocean Observing System with a coastal ocean measurement and dissemination component.

- For further information, contact Dr. Wayne Wilmot, NOAA, N/OES33, Coastal and Estuarine Oceanography Branch, Room 818, 6010 Executive Boulevard, Rockville, Maryland 20852, (301) 443-8510, FAX (301) 443-8300, TDD (301) 443-8513, or Mr. Lee Chapin, Mote Marine Laboratory, 1600 Ken Thompson Parkway, Sarasota, Florida 34236, (813) 388-4441, FAX (813) 388-4312.

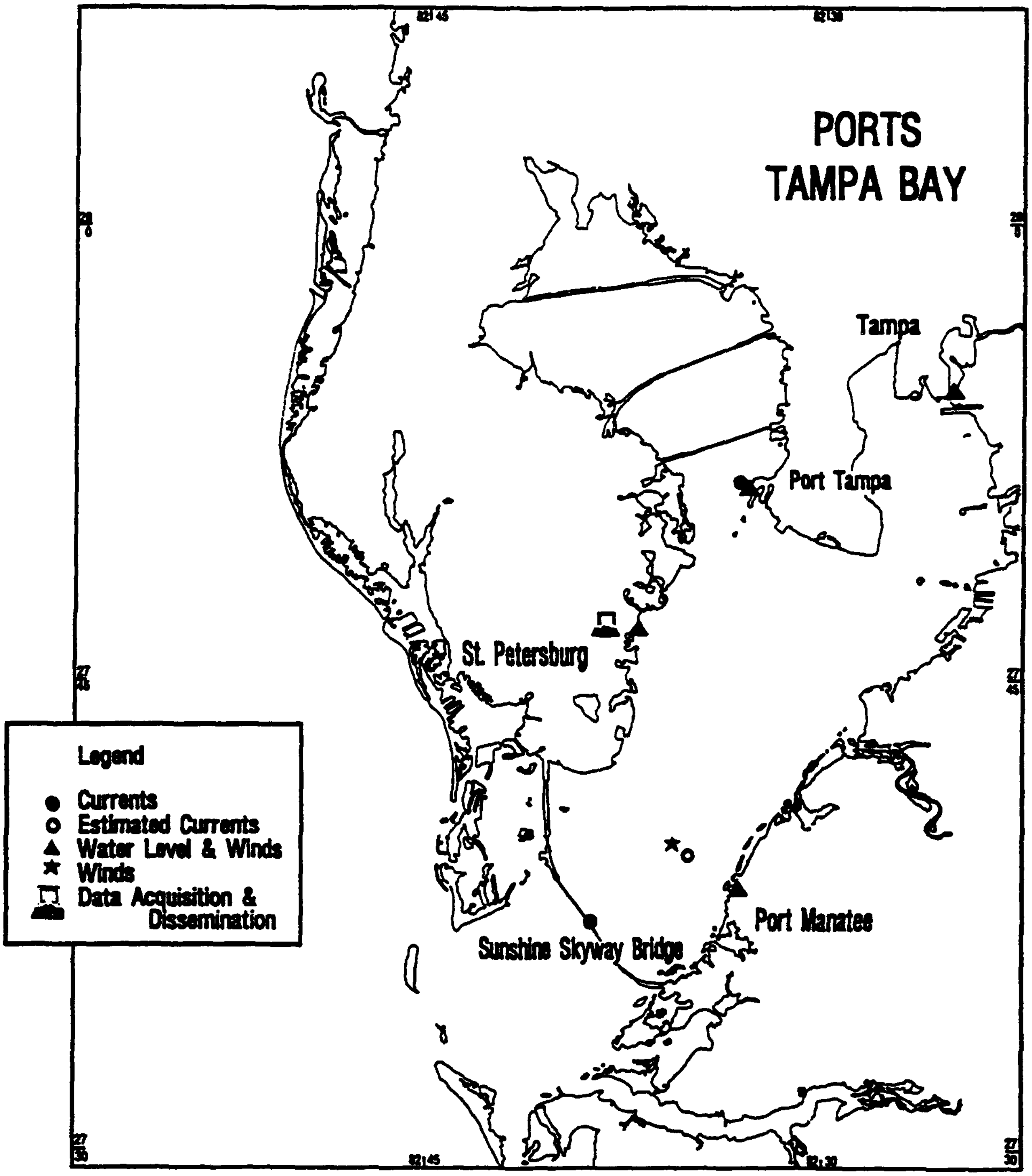


Figure A.6
Tampa Bay Physical Oceanographic Real-Time System (PORTS) sensor locations

A.8: National Park Service — Long Time Series Monitoring

Long-term monitoring projects within coastal U.S. National Parks are summarized below. If more specific information is desired regarding these projects, the individual park resource managers may be contacted. Figure A.7 shows the location of the coastal areas for which the National Park Service is responsible.

North Atlantic Region

1. Acadia National Park

Sand Beach, a small pocket beach within the Park, has been surveyed twice a year since 1981 to examine shoreline profile changes.

Intertidal biota are inventoried on hard and soft substrates twice a year. Permanent transects have been established and surveyed at least twice a year since 1988.

2. Cape Cod National Seashore

Shoreline and cliff-top migrations are monitored through the use of aerial photographs and beach and dune profiles. Data dates to 1938.

Piping plover and tern nests have been monitored once a day during the nesting season since 1976.

Salt marsh accretion rates have been taken annually at four sites in Nauset Marsh, using feldspar marker horizons since 1990.

3. Fire Island National Seashore

Dune crest migration has been monitored through the use of digitization of aerial photographs at five-year intervals since 1976. Beach and dune profiles have been performed at least once a year since 1983 to document dune crest migration.

Bathymetric changes have been documented from 1938 to 1978, out to 10 meters offshore.

4. Gateway National Recreational Area

Beach profile surveys have been conducted semi-annually at Sandy Hook since 1985.

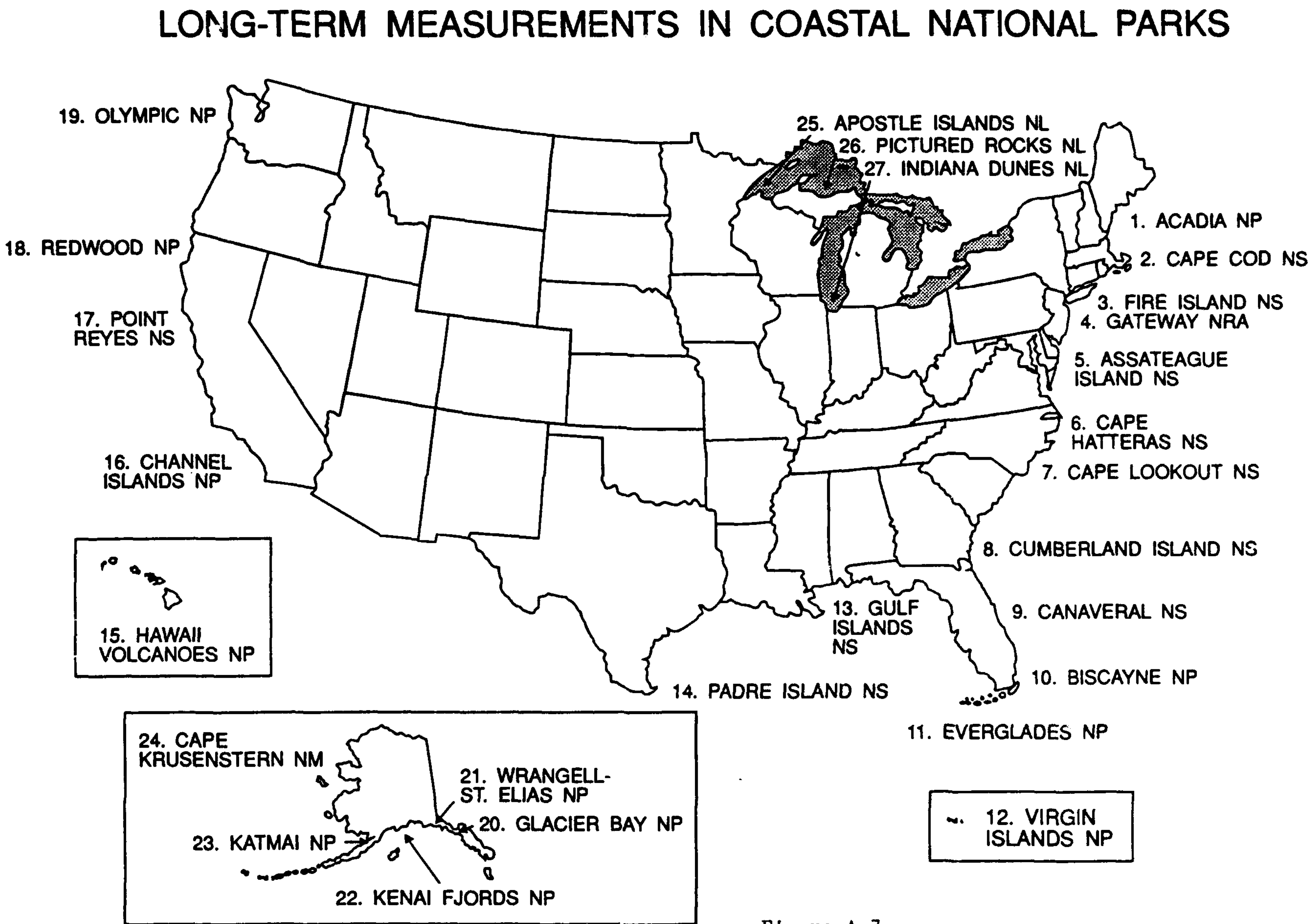

LONG-TERM MEASUREMENTS IN COASTAL NATIONAL PARKS
1. ACADIA NP
2. CAPE COD NS
3. FIRE ISLAND NS
4. GATEWAY NRA
5. ASSATEAGUE ISLAND NS
6. CAPE HATTERAS NS
7. CAPE LOOKOUT NS
8. CUMBERLAND ISLAND NS
9. CANAVERAL NS
10. BISCAYNE NP
11. EVERGLADES NP
12. VIRGIN ISLANDS NP
13. GULF ISLANDS NS
14. PADRE ISLAND NS
15. HAWAII VOLCANOES NP
16. CHANNEL ISLANDS NP
17. POINT REYES NS
18. REDWOOD NP
19. OLYMPIC NP
20. GLACIER BAY NP
21. WRANGELL-ST. ELIAS NP
22. KENAI FJORDS NP
23. KATMAI NP
24. CAPE KRUSENSTERN NM
25. APOSTLE ISLANDS NL
26. PICTURED ROCKS NL
27. INDIANA DUNES NL

Figure A.7

Mid-Atlantic Region

5. Assateague Island National Seashore

Shorebirds have been surveyed twice a month since 1984.

Vegetational changes have been monitored on two island sites since 1972.

Submerged aquatic vegetation on the Park's bayside has been monitored once a year since 1984.

Southeastern Region

A barrier island remote sensing and Geographical Information Systems (GIS) project has been conducted by the GIS group at the University of Virginia that covers the National Park Service's Southeastern region. Included in this region are the following parks: Cape Hatteras, Cape Lookout, Cumberland Island, Timucuan, Canaveral, Biscayne, and Gulf Islands. For each of the parks, the following tasks have been completed: 1:100,000 maps digitized, 1:24,000 maps digitized, NWI (Naval Warfare I: I stands for North Atlantic) maps digitized, ecological inventory, cultural inventory, miscellaneous maps, scanned images, GPS points established, and georectification of photographs.

Southeast Region

6. Cape Hatteras National Seashore

The North Carolina Department of Transportation has been conducting an inventory and monitoring study for faunal and geomorphological parameters off of Pea Island National Wildlife Refuge since 1992.

A shoreline risk assessment project began in 1992 for the Park. GPS points are currently being established and surveyed.

7. Cape Lookout National Seashore

Sea turtles and their nesting sites have been monitored during the nesting season since the early 1980's.

Annual shorebird surveys have been conducted since 1990 in the Park.

8. Cumberland Island National Seashore

Beach and offshore bathymetry are surveyed annually and after major storms. Permanent stations are located around the Park's perimeter at 400 meter intervals. The surveys have been conducted since 1988 on the southern half of the island. The entire island will be included in 1993.

Aerial photographs are taken of the island annually by NASA. Photography is scanned, georectified, and entered into the Park's database. Aerial photographs have been acquired since 1988.

Meteorological data, including evaporation, have been collected hourly at three park stations since 1989.

9. Canaveral National Seashore

The Park has been monitoring the effects of revetment construction, just north of the Park boundary since 1984.

Within the dunes are six stations that are surveyed bi-annually and after major storm events to detect dune face erosion.

10. Biscayne National Park

Water quality has been monitored in the Bay and on the reef area for two years continuously. Bay samples are taken every 28 hours and there is permanent equipment on the reef that samples once an hour.

Submerged aquatic vegetation has been monitored in the Park since 1990.

11. Everglades National Park

The Park has established 29 long-term physical monitoring stations within its marine areas. Daily and monthly measurements of physical parameters are recorded.

12. Virgin Islands National Park

Coral reef long-term monitoring projects within the Park include: recording of water temperatures every two hours since 1989; percent cover surveys twice a year since 1989; recording of shallow reef communities disturbances once a year since 1987; and reef fish and invertebrates have been monitored annually since the mid-1980's.

13. Gulf Islands National Seashore

Mississippi

The beach on West Ship Island is nourished every 4 years. Beach profile surveys are conducted once every quarter.

Marine mammal and turtle strandings have been monitored as observed since the late 1970's. Turtle nesting activity has been monitored annually since 1988.

Threatened and endangered avifauna are monitored annually since 1986 for an index of productivity.

Florida

The Perdido Key beach renourishment project began in 1989 and includes annual monitoring of marine benthic invertebrates, terrestrial vegetation, physical processes, and the endangered Perdido Key beach mouse.

Neotropical migratory and wintering coastal waterbird surveys have been conducted since 1990.

Marine debris monitoring has been conducted four times a year at six sites within the Park since 1989. Water quality has been monitored daily on West Ship Island for water temperature and salinity since January, 1991.

Marine mammal strandings are monitored as observed. Sea turtle surveys have been conducted three times a week from mid-May to August since 1989.

In Mississippi and Florida, a new grassbed monitoring and herpetological survey beginning this year will develop into long-term monitoring projects.

Southwestern Region

14. Padre Island National Seashore

Colonial nesting waterbirds have been annually surveyed since 1972. A project that monitors neotropical birds began in 1993.

Observations of sea turtles have been recorded since 1989, and a stranded sea turtle patrol began in 1986.

A hydrocarbon and contaminant analysis began in 1993 to gather baseline information on the soils and sediment contaminant levels. Samples are taken annually from twelve sites around the park. Data will be utilized to perform natural resource damage assessment following an oil or chemical spill within the Park.

Benthic invertebrates have been inventoried and monitored at several sites around the Park since 1992 to gather baseline information on their distribution and abundance.

A hydrogeologic resource survey began in 1993 to determine the expanse, dynamics, and water quality of the Park's underground water resources.

Western Region

15. Hawaii Volcanoes National Park

Hawksbill sea turtles have been monitored along two beaches within the Park daily during nesting season since 1987.

Vegetational trends have been monitored through the use of permanent transects since 1985 to determine the extent of non-native species.

A beach dynamics study began in the late 1980's to examine the role of lava flow in shoreline change.

16. Channel Islands National Park

The rocky intertidal community has been monitored through biannual surveys since the early 1980's.

Physical properties for sand beaches and coastal lagoons have been monitored annually since the mid-1980's.

A long-term pinniped monitoring project examines the annual population changes in four species that occur within the Park.

17. Point Reyes National Park

Air quality, visibility, and particulate matter have been measured and recorded monthly since 1987.

18. Redwood National Park

The Redwood Creek estuary has been monitored since 1980 to document changes in its physical structure and processes.

Annual topographic and cross-section surveys have been conducted, as well as several years of continuously recording water levels and aerial photography.

Pacific Northwest Region

19. Olympic National Park

A long-term ecological monitoring project began in 1992 to survey faunal and floral populations on all substrate types within the Park.

Alaska Region

20–24. Cape Krusenstern National Monument, Glacier Bay National Park, Katmai National Park, Kenai Fjords National Park, Wrangell-St. Elias National Park

Vertebrate threatened and endangered species are monitored in all Alaskan national parks by monthly to annual counts, aerial fly-overs, and capture–release programs.

Midwestern Region

25. Apostle Island National Lakeshore

A long-term program to monitor migratory birds in the Park was begun in 1990. Direct counting at observation points is used to determine migratory flow (birds/hour) and species composition. Spring and fall surveys are also completed at several sites around the Park.

Sandscape vegetation monitoring began in 1988 using the step-point method in the dune and intertidal zones. Baseline information is collected on dune vegetation, changes through time, and the impact of visitor use. Monitoring frequency varies from 1–5 years at 19 monitoring sites.

In 1989, a long-term bluff erosion monitoring project began and is now performed every 3 years. The goal is to determine the rate of bluff retreat through periodic measurements of established baselines.

26. Pictured Rocks National Lakeshore

Shoreline movement has been assessed by semi-annual surveying of transects along the Park's shoreline since 1986.

Rare plants have been monitored and correlated with geomorphological features since 1985.

Appendix B: Abstracts of Presentations

Title: High Latitude Coastal Ocean Time Series
Author: Thomas C. Royer
Affiliation: Institute of Marine Science, University of Alaska

In December 1970, hydrographic sampling at a coastal site (60°N, 149°W) was begun in the northern North Pacific. Temperature and salinity versus depth have been measured to the bottom, 263 m. The site is located at the mouth of Resurrection Bay, near Seward, Alaska, and it happens to be in the core of the Alaska Coastal Current that is a major circulation feature. This is also an important marine ecosystem feature for the entire region. This site was initially selected for its location near an oceanographic facility (Seward Marine Station operated by the University of Alaska) and sampling was done on an ad-hoc basis as research vessels entered and departed from that facility. More recently, the sampling has been more formally conducted from a small boat on a regular monthly basis.

Ocean temperature in the upper 250 m in the northern North Pacific increased by more than 1°C from 1972 to 1986, but is now decreasing. Subsurface temperature anomalies are well correlated ($\sim$ 0.58) with the air temperature anomalies at Sitka, Alaska, hence the coastal air temperatures can be used as a proxy data set to extend the ocean temperature time series back to 1826. Up to 30 percent of the low frequency variance can be accounted for with the 18.6 year nodal signal. Additionally, spectral analysis of these air temperature variations indicates a significant low frequency peak in the range of the 18.6 year signal. Similar low frequency signals have been reported for Hudson Bay air temperatures since 1700, for sea surface temperature in the North Atlantic from 1876 to 1939, and for sea level in the high latitude, southern hemisphere. The water column temperature variations presented here are the first evidence that the upper ocean is responding to this very long period tidal forcing. An enhanced high latitude response to the 18.6 year forcing is predicted by equilibrium tide theory, and it should be most evident at latitudes poleward of about 50 degrees. These low frequency ocean–atmosphere variations must be considered in high latitude assessments of global climate change since they are of the same magnitude as many of the predicted global changes. El Niño–Southern Oscillation events are evident in the thermal records but are relatively short lived as compared to the interdecadal temperature variations.

The 18.6 year lunar nodal tide can also account for 59% of the variance of the halibut biomass in the Gulf of Alaska. It is unknown what is the cause for this response. Is it direct reaction to temperature or is it a response to food supplies or something else linked to the 18.6 tidal effect? Interdecadal changes in primary production for this region have been reported recently, but there have been few measurements of primary production and nutrients in the North Pacific. To extend our knowledge of these temperature fluctuations to understand better the fluctuations of the marine ecosystem, we must expand the measurements to include nutrients, primary production

and larval fish. These measurements need to be made on interdecadal time scales with monthly sampling. The conclusions of these studies should be applicable to other high latitude regions in the world.

Specifics of the time series are as follows:

Site: Seward, Alaska (59°50.7'N, 149°28.0'W), Water depth, 263 m.

Sampling: Temperature and salinity versus depth.

Duration: Since December 1970 to present.

Frequency: Irregular to 1990, approximately monthly since May 1990.

Availability of data:

The data are available via Internet in anonymous ftp by the following:

ftp hayes.ims.alaska.edu [or ftp 137.229.20.400]

username: ftp

password: your email address

ftp> cd ctd

ftp> get gakl.dat

ftp> bye

There is also a metadata file in the same directory called README.

Title: Fisheries-Oriented Long Time Series Off the U.S. West Coast

Author: Paul E. Smith
Affiliation: NOAA/National Marine Fisheries Service
La Jolla, California

A research consortium known as the California Cooperative Oceanic Fisheries Investigations or CalCOFI, was formed in 1947 to discover the physical and biological oceanographic causes for the collapse of the Pacific sardine population, which in the previous two decades had been a major California industry and one of the most important fisheries in the world with an annual yield of a half-million tons. The consortium began a massive oceanography program covering the coastline of California and Baja California, Mexico, out to a distance of 300 nautical miles at the monthly time scale. The major players through time were the National Marine Fisheries Service Coastal Division, the University of California, Scripps Institution of Oceanography, Marine Life Research Group, and the California Department of Fish and Game Marine Division.

Now 44 years later we have amassed the data from these surveys, catch analyses of the fisheries, and meteorological data. The first breakthrough in the analysis of these data occurred in 1967 with the publication of the 1000-year record of fish scales deposited in varved anaerobic sediments of the Santa Barbara Basin. The perception that the sardine population varied strongly in runs of decades changed the interpretation of the fisheries' effect on renewable resources and the relative importance of long-term shifts in the environment. It may be that the shift in 1947 and the resumption of population growth after 30 years in 1977 would have to be considered as a major time-scale of variability in fisheries management and evaluation of the environmental effects on populations.

Title: Lessons from Long Time Series in the Southern California Bight
Author: Alessandra Conversi
Affiliation: State University of New York, Stony Brook

The purpose of the presentation was twofold:

1. To explain the kind of information we can get from biological long time series, i.e. the rationale for collecting samples at regular intervals over a long time period.
2. To share the lessons that I derived from analyzing existing decadal water quality monitoring data in the Southern California Bight.

1. The Rationale for Long Time Series

There are at least three reasons for which long time series collection is necessary:

a) Understanding decadal variability.
Biological properties naturally vary at all time (and space) scales, yet the relative importance of the various scales of the variability is not understood. Identifying patterns of variability is the first step toward understanding the forces underlying them.

The importance of diel, tidal and seasonal fluctuations has been recognized for a long time, but it is now becoming clear that there are powerful changes at the interannual range. Long time series are now needed to understand a new temporal scale of investigation: decadal to centennial. The few existing decadal series are already shaping a new picture. They have indicated that many biological (and physical) properties are highly variable at the interannual scale (i.e. pier chlorophyll, McGowan). Wherever grid or transect sampling exists (CalCOFI, continuous plankton recorder), it can be seen that interannual changes can cover entire oceanographic regions. In fact, some kind of direct relationship between the spatial and the temporal extension of an event is now taking shape.

b) Defining large scale cause–effect relationships.
Some non-intuitive relationships can be detected in long time series variables: for example the relationship between California Current zooplankton biomass and the strength of the southern transport (CalCOFI data). Or climate–biology relationships, such as the similarity in decadal trends in zooplankton biomass and in westerly wind data (CPR data).

c) Distinguishing between natural and anthropogenic variability.
Humans have now gained the ability to influence the planet strongly, with consequences yet unassessed. One of the daunting tasks facing scientists is to be able to distinguish anthropogenic from natural variability. We are still far from this ability, since our understanding of basic natural variability is weak. Yet, this is going to be one of the

highest research priorities in the near future. We need long time series as a step toward the understanding of the natural systems, which is needed for the understanding of the anthropologically modified ones.

2. Lessons from the Southern California Bight

The following are some recommendations derived from my own experience dealing with water quality data monitored for 15 years near three sewage outfalls in the Southern California Bight. These recommendations can be applied to other marine monitoring programs.

a) There is the tendency, both among scientists and in federal agencies, to plan new, expensive, global monitoring plans, while disregarding the many existing local and state mandated, "non-scientific" monitoring programs. This happens because these programs are largely unknown, and because there is concern about their methodology and data quality. Yet, these programs can provide good quality uninterrupted time series, sometimes decades long. Since there is still uncertainty on what information can be extracted from monitoring programs, *it is important to test monitoring questions on the existing programs,* and this should be done *before* making new plans. Funding should be allocated toward the recovery of the existing historical time series.

b) When planning a monitoring program, the temporal scale of sampling should be carefully evaluated, since it delimits the upper and lower frequency boundaries of the phenomena to be investigated. Meaningful spectral analysis requires band/ensemble averaging of the data, de facto reducing the lower frequency resolution, while, on the other side, the highest detectable cycle (Nyquist frequency) corresponds to twice the sampling frequency.

c) In most cases the sampling frequency is chosen for logistical reasons (such as cost, laws, etc.). If the sampling frequency is too low to detect some dominant high frequency energy, aliasing may occur, which could invalidate the time series. High frequency short term sampling should be done prior to the beginning of the monitoring program in order to evaluate the importance of high frequency energies.

d) In many cases it has been seen that low frequency signals have large spatial extent. Regional sampling (i.e. similar properties, methods, frequencies, patterns) should be the approach to a comprehensive monitoring plan.

e) Because of the cost of the monitoring on one side, and given that on the other side there are many local monitoring programs mandated by Federal and State laws, a regional monitoring program should include and coordinate local monitoring plans. There should also be more involvement/exchange between academia and Federal and State agencies in designing and utilizing even the monitoring programs intended for local use.

f) The questions to be asked have to be clearly defined in advance of designing the program. For example, most of the State mandated monitoring sampling is targeted toward compliance, and as a consequence there is little interest in the preservation or in the analysis of the historic data. The historical data may be lost, or in some cases methods may be changed from year to year, nullifying the time series. Monitoring programs are too expensive to be utilized for compliance only. Understanding the variability of the sampled properties should be part of their mandate.

g) There is the need of investing more resources toward the development of mooring techniques for biological variables.

Title: Use of Long Time Series Fishery Data in the Northeast
Author: Steven A. Murawski
Affiliation: National Marine Fisheries Service

Marine fisheries of the Northeast USA have for centuries provided food, employment and recreation for the region's inhabitants. The necessity to collect information on the magnitude and variability of catch and associated variables was recognized early on as a priority. Over the years, the data collection scheme has evolved to include a complex array of information which allows scientists and managers to track the year-to-year variation in fishery populations. The need to view fishery yields in the context of ecosystem productivity has resulted in a widening of the definition of 'fishery data' to include the measurement of biological and physical parameters likely to influence fishery production in direct or indirect ways. This paper briefly outlines the types of long time series data generally available for the Northeast fisheries, and the uses currently made of these data. The focus of this talk is on waters of the exclusive economic zone (EEZ) beyond the 3-mile territorial seas of the states, although similar data are collected for inshore areas.

Fishery Dependent Data

Fishery dependent data are defined as measurements that are made directly from the catch of either commercial or recreational fisheries. The types of fishery dependent measurements made for Northeast fisheries, and the approximate lengths of time series are given in Table B.1. Primary data on the quantity (weight) of landings has been collected since the 1880's. In the early years before the 1920's, these surveys of landings were intermittent, because of the logistical problems associated with collecting and assembling catch data from the vast network of small ports along the Northeast coast. Since the 1920's, landings data have been summarized for each year.

Beginning in the 1930's, a network of vessel sampling was initiated, which included routine interviews of captains for effort (days, hours, sets fished), and biological measurements of the landings for length and age composition. Thus, for example, the Georges Bank haddock stock includes catch-at-age data from 1931 to the present. The priorities of catch and effort sampling have shifted over the years, but the current scheme includes a network of data collection in all major fishing ports of the Northeast.

Other types of fishery-dependent data routinely collected include sampling and estimation of recreationally-caught fish, and basic economic information including revenue, imports, trade and holdings. One of the newest systematic data sets includes information derived by trained observers aboard commercial vessels (sea sampling). This data set is intended specifically to estimate the portion of the catch that is discarded at sea. The loss of potential yields through the discards of undersized fish or

Table B.1: Types of Fishery Data Collected for the Northeast USA EEZ

1. Fishery Dependent Data

   a. landings (1880's to present)
   b. effort, location (1930's to present)
   c. biological characteristics (1930's to present)
   d. sea sampling aboard commercial vessels (1989 to present)
   e. recreational catch/effort (1979 to present)
   f. economic data (1930's to present)

2. Fishery Independent Data

   a. bottom trawl surveys (1963 to present)
   b. sea scallop surveys (1975 to present)
   c. northern shrimp survey (1984 to present)
   d. surf clam/ocean quahog survey (1965 to present)
   e. ichthyoplankton surveys (1970's to present)
   f. continuous plankton recorder (1970's to present)
   g. temperature observations (variable)
   h. benthos surveys (intermittent)
   i. primary production (intermittent)

Table B.2: Uses of Fishery Data Collected in the Northeast EEZ

1. Index trajectories of stocks (relative indices of abundance)
2. Tune cohort models of stock size
3. Predict recruitment to exploited stocks
4. Monitor the geographic distribution of landings
5. Research effects of environmental variability on production and availability
6. Research effects of species interactions
7. Research ecosystem-level effects of harvesting
8. Research biological–economic implications of management strategies

unmarketable species is an increasing concern in fishery management, and accurate accounting for discards may be important for forecasting.

Fishery Independent Data

Fishery independent data is information not taken directly from the results of fishing operations. There are several potential biases that may occur if only fishery-dependent data are used to evaluate stock status. The fishery may not take place in all areas occupied by the stock, likewise, the fishery may concentrate on valuable size and age groups, which may misrepresent the true distribution of the stock. For these and other reasons, it has long been recognized that statistically-based fishery independent sampling is important in the evaluation of resource productivity. The types of fishery independent data collected in the Northeast region are given in Table B.2.

In the Northeast region, the longest continuous fishery-independent data collection scheme is the series of stratified-random bottom trawl surveys, conducted since 1963 (Figure B.1). This program includes annual spring and autumn trawling surveys at pre-determined station locations all along the Continental Shelf from Cape Hatteras to Nova Scotia. Additional research vessel surveying schemes have been instituted for sea scallop, northern shrimp and ocean clams.

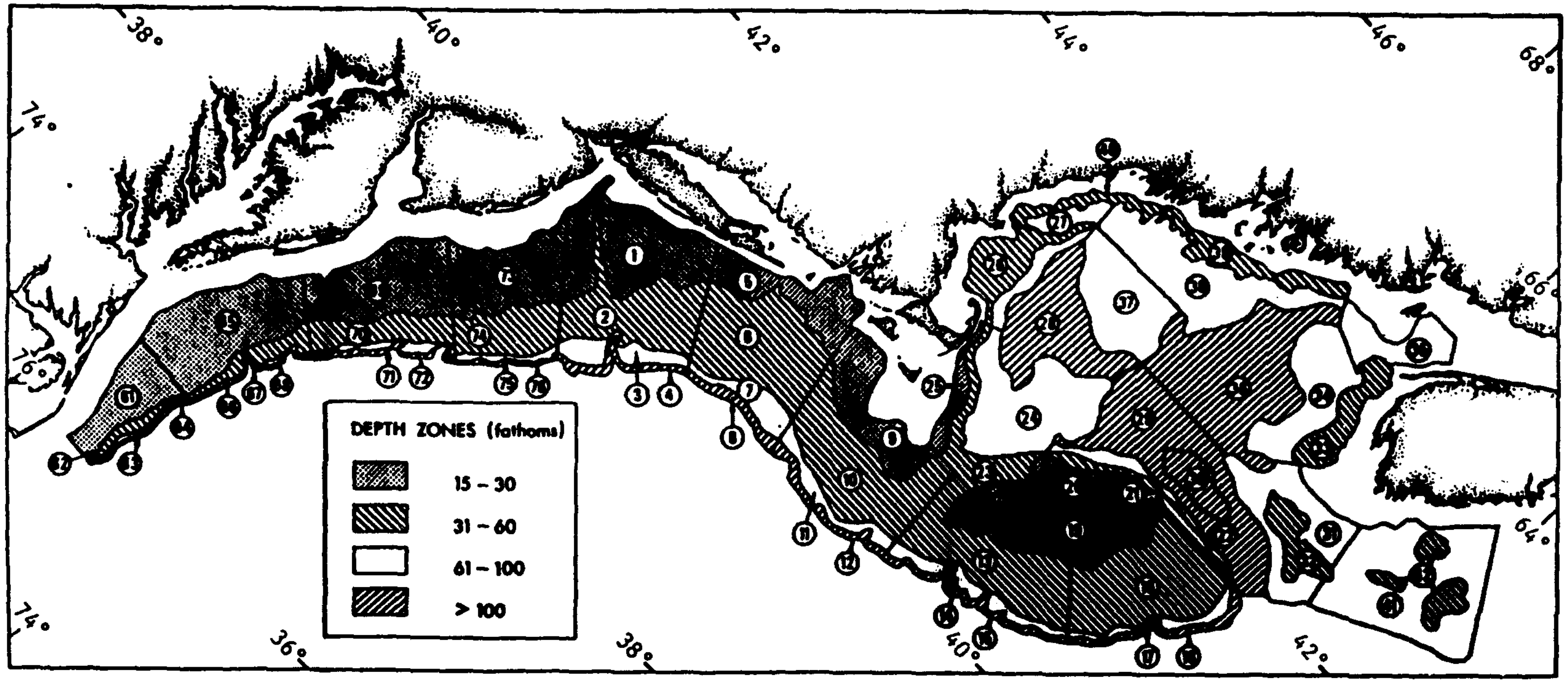


Figure B.1. Offshore bottom trawl survey strata off the Northeast USA, used in conducting stratified-random trawl surveys. Survey station allocation is generally proportioned to stratum area.

In order to understand the mechanisms controlling the production, variability and distribution of fishery resources, a variety of other data are routinely collected concerning the Northeast shelf ecosystem. These include ichthyoplankton surveys (net sampling), various temperature observations (either remotely sensed or in situ), continuous plankton recorder transects, and intermittent evaluations of benthic and primary productivity.

Uses of Time-Series Fishery Data

Data described above are used for two primary purposes: (1) to evaluate stock status and forecast fishery production, and (2) to understand the processes contributing to the level and variability in fishery yields.

Fishery independent surveys and catch-per-unit of effort statistics provide relative indices of stock abundance, which track the trajectories of resources over time (Figure B.2). These values can be used alone, or with catch-at-age data to tune cohort models of the abundance and rates of mortality of exploited stocks. Research vessel surveys conducted with small-mesh sampling gears provide indices of future recruitment to exploited stocks, thereby allowing forecasts. The changes geographic distributions of species are monitored based both on fishery dependent and fishery independent data. Understanding the complex processes that determine resource productivity involves a combination of long time series data and specific process-oriented studies. In particular, this research has focused on: (1) the influences of environmental variability on production and fishery availability, (2) the influences of predator/prey interactions (including the effects of marine mammals) on year class strength, (3) the ecosystem-level feedback effects of high, but species-selective harvest rates (e.g., on species composition, size, spectra, etc.), and the bioeconomic implications of alternative proposed harvest scenarios.

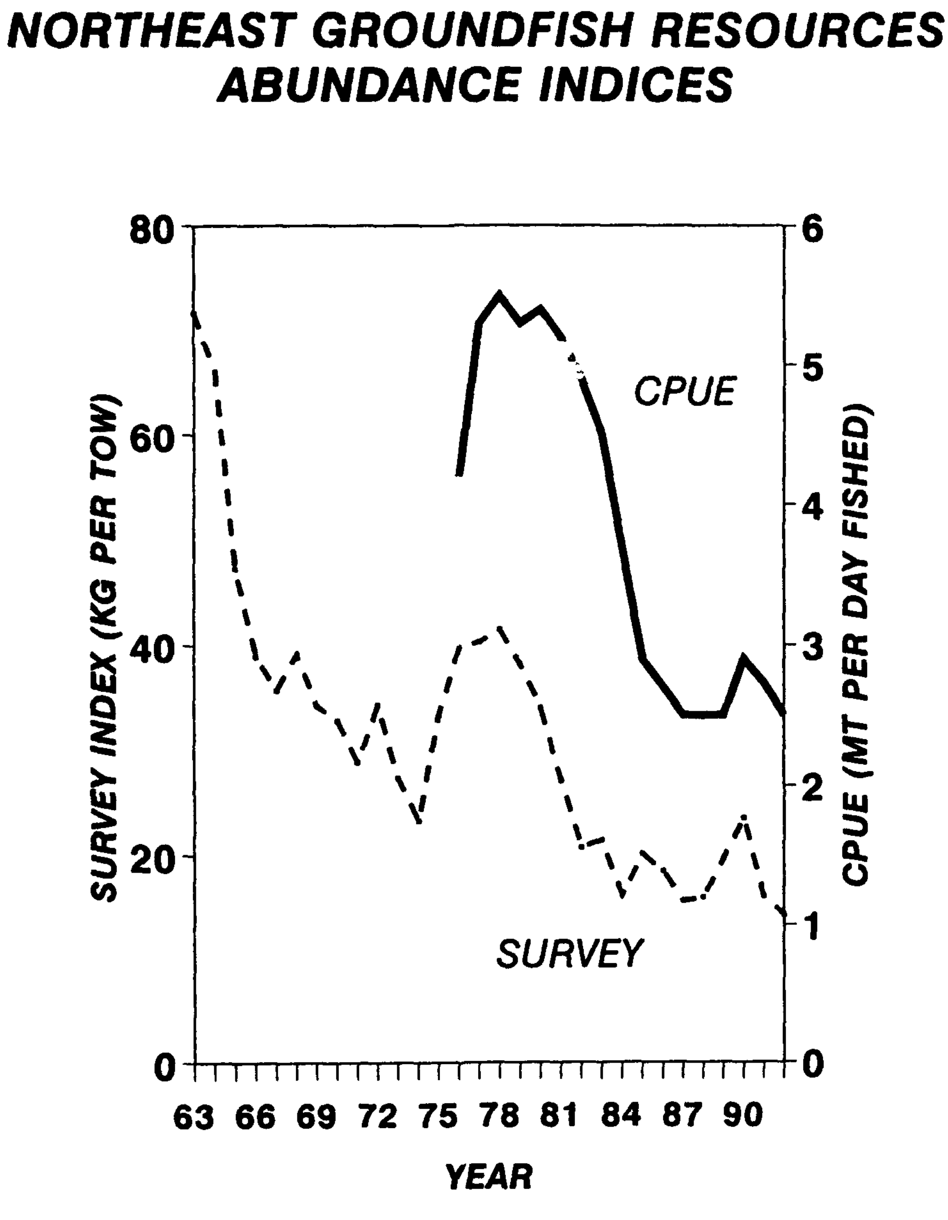


Figure B.2. Relative abundance indices from autumn research vessel trawl surveys and commercial catch per day fished for 12 species of Northeast groundfish, 1963–1992. Species include: Atlantic cod, haddock, pollock, silver hake, red hake, winter flounder, witch, yellowtail flounder, summer flounder, American plaice, redfish and windowpane.

Title: A 32-Year Environment–Plankton Time Series for Narragansett Bay
Author: Ted Smayda
Affiliation: Graduate School of Oceanography, University of Rhode Island

A 32-year (1959–1990), process-oriented quantitative time series on environment-plankton based on weekly measurements and supplemented by numerous ancillary laboratory and in situ experiments is available for a station located in Narragansett Bay. At maximal activity, 27 variables and processes were measured weekly. This appears to be the longest, quantitative plankton time series available globally. Physical measurements include river runoff, precipitation, wind speed, irradiance (incident and in situ), temperature, salinity and transparency. Chemical measurements include: NH_4, NO_3, urea, PO_4, SiO_2. Biological/physiological measurements include: phytoplankton and zooplankton species composition and numerical abundance, phytoplankton biomass as chlorophyll and ATP, particulate C and N, primary production; nutritional status based on nitrate reductase and alkaline phosphatase activity; zooplankton biomass as dry weight, C and N; gelatinous zooplankton (ctenophore) numerical abundance.

Significant long-term climatological changes characterize the 22-year period between 1959 and 1980 (remaining years to be analyzed). Annual wind speed and incident irradiance, which were correlated ($r = +0.73$), progressively decreased from 1973 to 1980. Temperature showed the opposite trend, and was inversely correlated with irradiance ($r = +0.56$). Annual mean temperatures were lowest during the 1960's, with a significant warming trend beginning in 1969. "Cold" and "warm" and "wet" and "dry" years (seasons) can be clearly discriminated in the time series. Associations occur between nutrient conditions and climatological and meteorological factors. Annual mean Si ($r = +0.56$) and NO_3 ($r = -0.76$) concentrations were correlated with irradiance; NO_3 ($r = +0.86$) with runoff; Si with water temperature ($r = +0.74$) and snowfall ($r = +0.71$); and relative to sunspot number, NO_3 was negatively ($r = -0.68$) correlated, and both Si ($r = +0.54$) and water temperature (+0.54) positively correlated.

Remarkable trends and changes in phytoplankton abundance and blooms occurred. Mean annual diatom abundance varied by ca. 3-fold, exhibiting three 5-year cycles of abundance between 1965 and 1980. Mean annual flagellate abundance increased significantly since 1974. Mean annual total diatom abundance during winter (January–March) progressively decreased by 20-fold between 1959 and 1978. In contrast, this was accompanied by a long-term summer increase (ca. 8-fold) in mean diatom abundance. Another dramatic change was the shift in the annual phytoplankton maximum from a winter–spring event to summer (August) in six of the nine years between 1970 and 1979. Long-term increases in primary production, phytoplankton and zooplankton biomass accompanied the above trends and changes.

High resolution time series such as available for Narragansett Bay are essential to understanding variability, status, trends, biotic responses to anthropogenic stresses and global change, including that in representative U.S. coastal waters. It is also essential to continue the Narragansett Bay time series.

Title: The Case for Long Time Series Measurements in the Coastal Ocean and Some Recent Samples

Author: Bradford Butman
Affiliation: U.S. Geological Survey, Woods Hole

Long time series observations of selected physical, chemical, biological, and geological properties should be initiated in the coastal ocean at a few key sites. Long time series are needed to define the time scales and the magnitude of ocean variability and to develop a description of the mean condition, as well as the seasonal, interannual, and climatic variability. Such descriptions are essential to distinguish successfully long-term trends, caused by anthropogenic effects or climate change for example, from natural variability. Analyses of long time series measurements often suggest hypotheses about processes operating in the coastal ocean and identify new directions for investigation. Long time series observations document catastrophic and (or) rare events that may play a critical role in the coastal ocean. For example, hurricanes, severe winter storms, or floods may dominate the transport of sediments, even though they occur only a small percentage of the time. Long time series data provide a range of conditions for model simulation and an important test for numerical and analytical models. Previous workshops have defined a coastal oceanography program for the United States and have recommended that long time series measurements of selected properties be an integral part of the nation's coastal research effort (Allen *et al.*, 1988; Brink *et al.*, 1992).

Long-term measurements of selected parameters at a few key sites on the continental margin will have important secondary benefits. They will provide reference measurements for the extensive spatial observations obtained by satellite. The long-term observation site can provide a location where the oceanographic conditions are well known and a platform and logistical support for testing of new instrumentation. The observation sites will provide high-quality measurements of certain basic parameters and thus serve as focal points for more detailed short-term interdisciplinary experiments, by placing them in a long-term context. The sites can eventually form the core of a national coastal observation system and the basis for real-time prediction of coastal conditions.

Existing long time series observations of coastal sea level and meteorology have been essential for coastal physical oceanographic experiments conducted over the last 20 years. Numerous current issues in coastal marine science, particularly those associated with global environmental change, can benefit from the perspective of long time series measurements of selected parameters. For example, the effects of El Niño, the importance of stratification in controlling the productivity of Georges Bank, biological changes in response to sediment contamination, the existence and causes of toxic algal blooms, the effects of introduced species, and the frequency and cause of hypoxia all would benefit from the hindsight of long term observations 50 years ago.

Collection of long-term observations presents unique challenges. Long-term observations require a stable and long-term institutional commitment, and data protocols and standards must be applied over the long term and be investigator-independent. Although applications and benefits of the observations will increase with time, funding for a long-term observational program may require continual justification in the early stages. Instrument research and development should be a integral part of the measurement program to ensure the active involvement of engineers and scientists necessary to produce high quality measurements. Innovative and creative technologies, especially to provide appropriate measurements inexpensively, should be encouraged. Fouling of traditional sensors will be an important challenge.

The following recommendations are suggested for consideration at this workshop:

- Identify existing long-term data series and ongoing programs in the coastal ocean. Existing programs with demonstrated useful data should be given priority for continued funding because of the past investment and the long start-up inherent in long-term observations.

- Define the scientific questions to be addressed by each long-term set of observations. Although many applications of the data will certainly result, the initial rationale for the site and properties must be clearly defined to focus initial analysis and to avoid monitoring for monitoring's sake.

- Initiate a set of standard observations at selected key locations (some of these may be at existing National Data Buoys). A high priority should be the collection of multidisciplinary measurements.

- Initiate long-term observations as an integral part of process and modeling studies to ensure appropriate rationale and to provide a regional understanding of the site-specific observations.

- Select long-term sites to define key processes, to represent major and diverse oceanographic systems, and to document pristine as well as stressed systems. Possible sites along the northeast coast of the United States include Georges Bank, Stellwagen Bank in the western Gulf of Maine, Narragansett Bay, midshelf in the Middle Atlantic Bight, and Chesapeake Bay.

- Solicit proposals for long-term observational programs from the research community and require investigators to provide the scientific rationale and techniques for selected long time series. New ideas, technologies and a healthy diversity of observations will result.

- Utilize proven technologies where possible; new technologies should be tested and evaluated at a few sites prior to widespread use. Involve the research community

in system development and evaluation to assure data quality and appropriate measurements.

- Encourage a diversity of measurements and approaches (range of technologies, data quality, institutional considerations) in addition to the standard observations. A diverse set of observations will provide new insights over the long term and ensure that a wide range of processes is documented.

- Encourage partnerships with Federal, State, local, and academic institutions. Develop standards for accuracy of selected properties, and utilize measurements made by others to develop a national network of observations. Exchange these data freely.

- Distribute data on a network, preferably in real time. Existing observations should be available digitally.

- Start observations immediately to maximize the duration and usefulness of time series observations.

References Cited

Allen, J., J. Bane, K. Brink (chair), D. Brooks, W. Brown, D. Caldwell, C. Collins, R. Guza, P. Jumars, and T. Royer (Steering Committee), 1988. Coastal Physical Oceanography: Towards a National Plan, Report of a meeting of the Coastal Physical Oceanography Community held January 23–26, 1988 in Gulf Park, Mississippi, sponsored by the National Science Foundation, 118 pp.

Brink, K. H., J. M. Bane, T. M. Church, C. W. Fairall, G. L. Geernaert, D. E. Hammond, S. M. Henrichs, C. S. Martens, C. A. Nittrouer, D. P. Rogers, M. R. Roman, J. D. Roughgarden, R. L. Smith, L. D. Wright, and J. A. Yoder, 1992. Coastal Ocean Processes: A Science Prospectus. *Woods Hole Oceanographic Institution Technical Report*, WHOI-92-18, 88 pp.

Appendix C: Long Time Series Variable Sheets

Introduction

The working groups were charged to define which variables should be measured in a coastal long time series effort, how they should be measured and why they are important. The following pages summarize the conclusions for each class of variable. An effort has been made to put each into a common format, but the sheets were filled in by individual attendees, so the style varies greatly.

Property:	Basic physical properties: waves, winds, atmospheric pressure, temperature.
Where:	Estuaries, coastal zone, shelf (land-based and buoys).
When:	Hourly.
How Used:	Weather warnings and forecasts; engineering; fishing.
Why:	These are basic measurements that support all at-sea studies, as well as being used for warnings and forecasts.
Benefits:	Savings of life and property; information on climate change; better warnings and forecasts — latter translates directly to economic benefit.
Logistical Support:	NOAA, NWS, U.S. Coast Guard (Data distribution) (Ships and aircraft)
New Technology:	New buoy hulls and electronics, better anemometers.

Notes: These are measurements at a point. Ideally, the network density would be such that all unique regimes are covered. Realistically, the network should be densest closest to the coast and less dense offshore.

Property:	Water level.
Where:	Presently measured at 189 sites (spacing based on tidal length scales; redundant for seasonal/interannual variability).
When:	Continuous (6 minutes–hourly).
How Used:	Sharing boundary datums, navigation, storm surge, dynamic modeling, indicator for climate and global change (sea level rise), coastal erosion.
Why:	See "How Used."
Benefits:	See "How Used."
Logistical Support:	Presently carried out operationally by Federal agency (NOS) with permanent field parties.
New Technology:	Acoustic measurement (half of national network so far) near-real-time (GOES).

Notes:

- Integrative property; coherence length scales increase in an understandable way with time scale.
- New rapid-sampling acoustic technology will allow long-term measurement of waves.
- New system accepts up to 11 ancillary sensors (typically, but others are possible) [including temperature at several levels].

Property:	Currents.
Where:	Entrances to estuaries and at meteorological buoys.
When:	Continuous.
How Used:	Transport (pollutant, sediment, etc.), navigation (for specific locations), spill clean-up, search–rescue, etc.
Why:	See "How Used."
Benefits:	See "How Used."
Logistical Support:	Requires field party.
New Technology:	ADCP (bottom-mounted or buoy-mounted).

Notes:

- Not integrative.
- Local effects (e.g. topography) greatly affect signal.

Property:	Salinity.
Where:	Coastal boundary, open shelf, estuaries.
When:	Continuous (fixed platforms), bottles, vessels of opportunity.
How Used:	Direct measurement of essential physical characteristics of coastal ocean.
Why:	Simple measurement important for physical and biological studies; key measure of river influence, habitat for species; helps determine stratification.
Benefits:	Document coastal buoyant plumes, water column stratification contribution of river water, along-shelf advection, variability of biological habitats.
Logistical Support:	Modest for shelf.
New Technology:	Technology exists — some long-term calibration and fouling problems.

Notes: Modest fouling problems in upper 10 m.

Property:	SST, Color.
Where:	From satellite — all of coastal ocean.
When:	At given sampling (3 days).
How Used:	Biomass, current estimates, onset of spring bloom.
Why:	Timing of spring bloom could be critical for recruitment; phytoplankton biomass is measure of productivity and health.
Benefits:	Would help in fisheries, toxic bloom and pollution studies.
Logistical Support:	Ground based — need distribution and digitization to time series, archiving.
New Technology:	None.

Notes: Existing (or nearly) measurements that can be more systematized, and subsets (condensed products) distributions.
Coastal color algorithms need refinement.

Property:	NO_3, NH_3, Si and their ratios.
Where:	Rivers, onshore/offshore gradients, long-term monitoring stations.
When:	High frequency in river/monitoring stations; periodically along gradients.
How Used:	To establish riverine fluxes to assess nutrient changes (trends), temporally; to assess role of physical advection of nutrients (NO_3) vs. recycling (NH_4) to evaluate potential of "creeping eutrophications;" to evaluate potential for harmful bloom species events.
Why:	Nitrification accompanying anthropogenic activities is commonplace and represents potential food-web degradation and dysfunction including toxic blooms, fish kills, recruitment losses, hypoxia and anoxia, or increased productivity potential.
Benefits:	Would help to establish need for hazard reduction strategies and/or remediation of increased nutrient reports; would also establish nutrient status and trends.
Logistical Support:	Ground-based analyses, archiving, digitization and processing.
New Technology:	In-situ measuring capability for nutrients. Alternatively, sample collection with storage capability for shore-based analyses.

Notes: High frequency (daily to weekly) measurement of integrated euphotic zone samples or fixed depth samples, dependent on objective of long time series. Multiple stations, with the station grid determined by objectives of long time series.

Property:	Chlorophyll (fluorescence).
Where:	On buoys, tide gauges.
When:	Continuous.
How Used:	In situ — self contained; data stored or telemetered.
Why:	Index of phytoplankton biomasses; link between physical forcing, nutrient input and higher trophic levels. Important in CO_2 drawdown.
Benefits:	Help understand the effects of anthropogenic inputs and global change on coastal productivity.
Logistical Support:	Need to calibrate and standardize Quality Assurance, Quality Control.
New Technology:	Exists but should be improved to reduce power requirements and provide the effect of fouling.

Notes: Could be problem with fouling in coastal zone. In-situ fluorometers should also be moored near bottom to assess cross-shelf transport and resuspension.

Property:	Suspended solids.
Where:	Coastal boundary, estuaries, open shelf.
When:	Continuous.
How Used:	Suspended solids concentrations as a function of space and time.
Why:	Particles carry contaminants; qualitative measure of flux of solids from land; ground-truth satellite observations; indication of bottom resuspension.
Benefits:	Estimates of particle distribution in coastal ocean; documentation of catastrophic or rare events.
Logistical Support:	Modest.
New Technology:	Light transmission; Laser-Doppler particle sizers.

Notes:

Property:	pCO_2, dissolved oxygen.
Where:	From NDBC and other maintained platforms.
When:	Hourly.
How Used:	Needed to estimate air–sea gas fluxes.
Why:	Measures of biological activity in the water column.
Benefits:	Measure of ecosystem health and of air–sea fluxes of greenhouse gas (CO_2).
Logistical Support:	From NDBC buoys.
New Technology:	

Notes: Technology is under development at Monterey Bay Aquarium Research Institute.

Property:	Atmospheric deposition (wet and dry) of nutrients/toxics NO_3, NO_2, NH_3, Hg, As, Cn, Cd, *etc.*
Where:	Estuarine and shoreline environments.
When:	Weekly/daily.
How Used:	Assess the importance of atmospheric deposition of toxics/nutrients to total loading; assess contribution of anthropogenic pollution to coastal environment (couple nutrient/toxics deposition with biological indicators as well).
Why:	Assess and predict anthropogenic impacts on coastal ecosystems via atmosphere deposition; predict response to emissions reductions (Clean Water Act).
Benefits:	Formulate control strategies to reduce atmospheric loading and deposition of anthrogenic pollutants.
Logistical Support:	Gridded networks of overland sampling stations (precipitation collectors, dry deposition monitors, etc.) Site operators needed!
New Technology:	Existing technology: wet collectors, dry deposition inferential monitors; chromatography, atomic absorption analysis.

Notes: Toxics/nutrient deposition from atmosphere is especially critical in Chesapeake Bay (due to large ratio of catchment to water volume). Also, important for estuarine and coastal environments in close proximity to urban environments (New York, Baltimore, Boston, etc.) Much of the deposition of toxics and nutrients is likely to be highly episodic (large storms, etc.)

Property:	Flux from land of fresh water, nutrients (Si, NO_3, NH_3), sediments and organic matter.
Where:	Representative rivers or watershed.
When:	Daily to weekly (keyed to discharge?)
How Used:	Information will be used to calculate nutrient loading to the continental shelf by multiplying concentration by freshwater discharge.
Why:	Fresh water, inorganic nutrients, sediments and organic matter are some of the key drivers controlling several important processes on the shelf (e.g., coastal currents, turbidity, sedimentation, toxic trapping, primary production). A significant source to the shelf of these components is the land. Land use make-up and management are changing rapidly, and we can assume concomitant changes in input will affect the shelf system.
Benefits:	An ability to understand causes of change observed on the shelf. Enables prediction of future loading based upon current patterns of land use and global climate change.
Logistical Support:	USGS (water survey).
New Technology:	In-situ detection of NH_3 and NO_3. Si, sediments and organic matters could be collected automatically in bottles, preserved and analyzed at a lab at a later date (auto-analyzed, gravimetric, high temperature catalytic oxidation, respectively).

Notes: Potential interaction with Land Margin Ecosystem Research program (LMER) and USGS river discharge monitoring network.

Property:	Indices of relative recruitment success.
Where:	Estuaries/coastal ocean, as appropriate.
When:	Annually, after the strength of cohorts is determined.
How Used:	Annual indices of recruitment strength are necessary to correlate with physical properties, chemistry, plankton production, and parental stock size.
Why:	Indices of recruitment strength are needed to deconvolve the relationships of environmental variability and harvesting policies to cohort size.
Benefits:	These indices provide leading indicators of fishery productivity, ecosystem health, and ecosystem change.
Logistical Support:	Existing and new shipboard and estuarine sampling programs.
New Technology:	Sampling strategies to dcvelop relatively precise recruitment strength, as early in the life cycle as possible.

Notes: Depending on the species, critical life stage sampling may occur in estuaries, near coastal areas, or offshore. Spatial extent of sampling varies, based on the dispersion of the critical life stage being sampled.

Property:	Acoustic estimation of zooplankton biomass.
Where:	On moorings — coastal buoys.
When:	Continuous.
How Used:	Biomass of zooplankton can be used to estimate grazing pressure and indicate the mass of food available to fish.
Why:	See "How Used."
Benefits:	Better understanding of relationships between physical forcing functions (temperature, wind) and ecosystem response.
Logistical Support:	Buoys
New Technology:	Now in developmental field-testing phase. Up and running by 1995.

Notes: Variation in zooplankton biomass on seasonal and interannual time scales may control recruitment in fish which depend upon zooplankton for food. Variations in biomass may be controlled in large part by variation in ocean physics, therefore we must be able to sample biomass and physical variables on the same time and space scales.

Property:	Species distribution of plankton.
Where:	At location where net/water samples can be made. From ships of opportunity.
When:	At least monthly interval to resolve seasonal differences.
How Used:	To indicate change, transient or permanent. Relating trophic levels and understanding recruitment.
Why:	Organisms are more sensitive to change than measuring systems; gives information on ecosystem response, specific organisms are known to be characteristic of different water masses — e.g., biological monitor of change.
Benefits:	Sensitivity and direct measurement of effect on ecosystem, association of reductionist assessments with holistic interpretation.
Logistical Support:	Labor intensive after collection. Use ships of opportunity.
New Technology:	Automated identification system required, e.g., image analysis, neural networks, molecular probes.

Notes: Conceptually the simplest of all measurements, but logistically the most expensive in time and of post-sampling effort.

Property:	"Health" of marine bird and mammal populations.
Where:	Coastal sites where birds and mammals aggregate.
When:	Birds: Every 2–3 days during nesting seasons; mammals — monthly.
How Used:	Birds: they integrate the coastal environment — variation in egg-laying rates, hatching success and percent fledglings are often correlated with environmental variability. Mammals: fat content and pup mortality rates can be used to indicate relative levels of coastal ocean productivity.
Why:	
Benefits:	Monitor food chain productivity by monitoring animals that are easily accessible on some land-based colony.
Logistical Support:	Graduate student.
New Technology:	None required.

Notes: Quite a lot has been done with monitoring coastal marine birds (off Peru, California and Alaska, as examples).
Sea birds give strong indications of the El Niño phenomenon.
Variations in nesting success of cassin's auklets at Pt. Reyes (California) seem to be related to the time of spring transition and to strength of El Niños.

Property:	Benthos-organisms living on/in bottom.
Where:	Selected sites.
When:	Annual to semi-decadal (dependent upon depth regions and as one goes from estuaries to off-shelf).
How Used:	Integrated biological measure of one component of marine ecosystems biodiversity, measure of benthic system.
Why:	• Organisms are restricted in their movement. • Benthic environment integrates flux through the water column to sediments. • Temporal variability less than typically observed in pelagic component.
Benefits:	• Integrates stresses exerted on benthic component of marine systems. • Important food component of many important fisheries.
Logistical Support:	• Ships with comparable sampling gears. • Processing labs to conduct consistent counting. • Archive samples. • Standard sampling/processing protocols.
New Technology:	• Acoustic/imaging techniques to replace traditional sampling approach.

Notes:

Property:	Benthic species composition and abundance.
Where:	Selected sites/regions (sediment and salinity are important stratification criteria).
When:	Yearly.
How Used:	*Quantitative counts of individual;* species spread of exotic species (like zebra mussel); local extinctions.
Why:	Low temporal and spatial variance at small scales. Integrated measure of ecosystems.
Benefits:	Most reliable and sensitive measure of anthropogenic change. Useful for 5 of 6 major issues (not for climate/weather).
Logistical Support:	Ships; platforms, Remotely Operated Vehicles (ROVs), and Autonomous Underwater Vehicles (AUVs) (surface and bottom platforms as support for taxonomy labs).
New Technology:	Optical–AUVs measuring on top of sediment, improves in remote type systems — within sediments.

Notes:

Property:	Metals and organic contaminants of environmental concern; human health (edible species and living natural resources).
Where:	Existing NOAA Status and Trends (bivalves and sediments).
When:	Less frequent than annual given existing set since 1986 — needs to be assessed from p[illegible]ent set of data.
How Used:	Assess large scale regions a[illegible] ty[illegible] of coastal use (e.g., urban versus rural agricultu[illegible] [illegible]nage).
Why:	Health of nearshore coastal ocean and estuaries in terms of chemical contaminants.
Benefits:	Documents effectiveness of laws and regulations controlling toxics (e.g., lead, PCBs, DDT) and continuing problems with other toxics (e.g., fossil fuel hydrocarbons). Allow regional comparisons.
Logistical Support:	Field sampling — labor intensive analyses — becoming less labor intensive data archives, etc.
New Technology:	"In situ" time integrating pump for water (also known as artificial "mussel") might be available in 2–5 years.

Notes:

- Has been reviewed independently external and internal to NOAA.
- Also includes periodic — every 5 to 10 years — assessment of historical records in sediment cores of selected deposition areas: it works on a regional basis.

Appendix D: List of Attendees

Frank Aikman
NOAA/National Ocean Service
Office of Ocean & Earth Sciences
Room 6543, SSMC4
1305 East-West Highway
Silver Spring, MD 20910
(301) 713-2809, Fax (301) 713-4501

John Allen
College of Oceanography
Oregon State University
Oceanography Admin. Bldg. 104
Corvallis, OR 97331-5503
(503) 737-2928

Rick Artz
NOAA/ARL
1325 East-West Highway
Room 9390
Silver Spring, MD 20910
(301) 713-0295

Ken Brink
Dept. of Physical Oceanography
Woods Hole Oceanographic Institution
Woods Hole, MA 02543
(508) 548-1400 ext. 2535

Mel Briscoe
NOAA/National Ocean Service
Office of Ocean & Earth Sciences
Room 10110, SSMC4
1305 East-West Highway
Silver Spring, MD 20910
(301) 713-2981, Fax (301) 713-4392

Bradford Butman
U.S. Geological Survey
Branch of Atlantic Marine Geology
Woods Hole, MA 02543
(508) 457-2211

Curt Collins
Dept. of Oceanography
Naval Postgraduate School
Monterey, CA 93943
(408) 656-2673

Alessandra Conversi
Marine Sciences Research Center
State University of New York
Stony Brook, NY 11794-5000
(516) 362-8700

John Farrington
Education Department
Woods Hole Oceanographic Institution
Woods Hole, MA 02543
(508) 548-1400 ext. 2200

John Gamble
Sir Alister Hardy Foundation for
Ocean Science
Plymouth Marine Laboratory
Citadel Hill
Plymouth, UNITED KINGDOM
(0) 752-222772

David L. Garrison
Division of Ocean Sciences, Room 609
National Science Foundation
1800 G Street, NW
Washington, DC 20550
(202) 357-9660

Gerald Geernaert
ONR Code 322MM
Office of Naval Research
800 North Quincy Street
Arlington, VA 22217-5660
(703) 696-2496

Robert Gelfeld
NOAA/NESDIS/NODC
Room 409
1825 Connecticut Avenue, NW
Washington, DC 20235
(202) 606-4571

Fred Grassle, Director
Institute of Marine & Coastal Sciences
Cook College
P.O. Box 231, Blake Hall
Rutgers University
New Brunswick, NJ 08903
(908) 932-6555 ext. 509

J. Michael Hemsley
National Data Buoy Center
NOAA, National Weather Service
Building 1100
Stennis Space Center, MS 39529-6000
(601) 688-2490

Carolyn Holmes
COE/CERC
Coastal Engineering Research Center
U.S. Army Corps of Engineers
Vicksburg, MS 39101
(601) 634-2025

Alicia L. Jarboe
NOAA/NMFS F/TS3
1335 East-West Highway
Silver Spring, MD 20910
(301) 713-2358

David Johnson
NOAA Coastal Ocean Program Office
1315 East-West Highway, Room 15137
Silver Spring, MD 20910-3233
(301) 713-3338, Fax (301) 713-4044

Walter R. Johnson
MMS-BEM, MS 644
381 Elden Street
Herndon, VA 22070-4817
(703) 787-1642

Suzette M. Kimball
NPS/CPSU
Department of Environmental Sciences
201 Clark Hall
University of Virginia
Charlottesville, VA 22903
(804) 924-1455

Thomas Kinder
ONR Code 321CS
Office of Naval Research
800 North Quincy Street
Arlington, VA 22217-5660
(703) 696-1206

Val Klump
Center for Great Lakes Studies
600 East Greenfield Avenue
University of Wisconsin-Milwaukee
Milwaukee, WI 53204
(414) 382-1700

Ron Lai
MMS-BEM, MS 644
381 Elden Street
Herndon, VA 22070-4817
(703) 787-1714

Richard Lambert
Program Director for Ocean Dynamics
National Science Foundation
Washington, DC 20550
(202) 357-9614

Michael Ledbetter
NOAA/NURP
1335 East-West Highway, Room 5240
Silver Spring, MD 20910
(301) 713-2427

Winston Luke
NOAA/ARL
1325 East-West Highway, Room 9390
Silver Spring, MD 20910
(301) 713-0295

Curt Mason
NOAA, Coastal Ocean Program Office
Room 15140
1315 East-West Highway
Silver Spring, MD 20910-3223
(301) 713-3338, Fax (301) 713-4044

Steven Murawski
NOAA/National Marine Fisheries Service
Woods Hole, MA 02543
(505) 548-5123

Bruce Parker
NOAA National Ocean Service
Room 6534, SSMC4
1305 East-West Highway
Silver Spring, MD 20910
(301) 713-2801

John Paul
U.S. EPA/ERL
Narragansett Laboratory
27 Tarzwell Drive
Narragansett, RI 02882
(401) 782-3037

William Peterson
NOAA National Marine Fisheries Service
F/RE3
1335 East-West Highway
Silver Spring, MD 20910
(301) 713-2367

Michael Reeve
National Science Foundation
1800 G Street, N.W.
Washington, DC 20550
(202) 357-9600

Michael Roman
University of Maryland
P.O. Box 775
Cambridge, MD 21613
(410) 228-8200

Jonathan Roughgarden
Dept. of Biological Sciences
Herrin Laboratory
Stanford University
Stanford, CA 94305-5020
(415) 723-3648

Thomas Royer
Institute of Marine Sciences
University of Alaska
Fairbanks, AK 99775-1080
(907) 474-7835

George W. Saunders
Office of Energy Research ER-75
U.S. Department of Energy
Washington, DC 20545
(301) 903-5548

Mike Sissenwine
National Marine Fisheries Service
1335 East-West Highway, Room 9358
Silver Spring, MD 20910
(301) 713-2239

Ted Smayda
Graduate School of Oceanography
University of Rhode Island
Kingston, RI 02881
(401) 792-6171

Paul Smith
NOAA National Marine Fisheries Service
P.O. Box 271
La Jolla, CA 92038-0271
(619) 547-7169

P. Ted Strub
College of Oceanography
Oregon State University
Oceanography Admin. Bldg. 104
Corvallis, OR 97331-5503
(503) 737-3015, Fax (503) 737-2064

Steven Swartz
NMFS, Attn: Code FX3
1335 East-West Highway, Room 9337
Silver Spring, MD 20910
(301) 713-2239

Charles Linwood Vincent
COE/CERC & NOAA
1825 Connecticut Ave., NW, Room 518
Washington, DC 20235
(202) 606-4330, Fax (202) 606-4334

Wayne Wilmot
NOAA National Ocean Service
N/OES331, Room 6515, SSMC4
1305 East-West Highway
Silver Spring, MD 20910
(301) 713-2803

Appendix E: Meeting Agenda

Workshop Agenda

Long Time Series in the Coastal Ocean

March 11–12, 1993

Thursday, March 11

0830 to 0900	*Registration and Viewing of Posters of Federal Agency Measurement Programs*
0900 to 0930	*Introduction and Charge to the Workshop*
	(Thomas Royer, University of Alaska; Linwood Vincent, Corps of Engineers)
0930 to 1030	*Some Examples of Existing Coastal Long Time Series and Their Applications*
	(P. Smith, A. Conversi, S. Murawski, T. Smayda)
1030 to 1100	Coffee Break and Poster Viewing
1100 to 1200	*Existing Federal Measurement Programs: A Summary of the Posters*
	(Michael Hemsley, National Data Buoy Center)
1200 to 1300	Lunch
1300 to 1330	*The Case of Long Time Series Measurements in the Coastal Ocean and Some Recent Examples*
	(B. Butman, U.S. Geological Survey)
1330 to 1615	*Working Group: Scientific Rationale for LTS Efforts*
	Refreshments available — no official break
1615 to 1700	*Presentation of Working Group Results*

Friday, March 12

0830 to 1100	*Working Group: A Practical Program for LTS Measurements*
	Refreshments available — no official break
1100 to 1200	*Presentation of Working Group Results*
1200 to 1300	Lunch
1300 to 1400	*Data Management*
1415 to 1430	Break
1430 to 1530	*Setting Priorities*
1530	Adjourn

DOCUMENT LIBRARY

Distribution List for Technical Report Exchange – July 1, 1993

University of California, San Diego
SIO Library 0175C (TRC)
9500 Gilman Drive
La Jolla, CA 92093-0175

Hancock Library of Biology & Oceanography
Alan Hancock Laboratory
University of Southern California
University Park
Los Angeles, CA 90089-0371

Gifts & Exchanges
Library
Bedford Institute of Oceanography
P.O. Box 1006
Dartmouth, NS, B2Y 4A2, CANADA

Office of the International Ice Patrol
c/o Coast Guard R & D Center
Avery Point
Groton, CT 06340

NOAA/EDIS Miami Library Center
4301 Rickenbacker Causeway
Miami, FL 33149

Library
Skidaway Institute of Oceanography
P.O. Box 13687
Savannah, GA 31416

Institute of Geophysics
University of Hawaii
Library Room 252
2525 Correa Road
Honolulu, HI 96822

Marine Resources Information Center
Building E38-320
MIT
Cambridge, MA 02139

Library
Lamont-Doherty Geological Observatory
Columbia University
Palisades, NY 10964

Library
Serials Department
Oregon State University
Corvallis, OR 97331

Pell Marine Science Library
University of Rhode Island
Narragansett Bay Campus
Narragansett, RI 02882

Working Collection
Texas A&M University
Dept. of Oceanography
College Station, TX 77843

Fisheries-Oceanography Library
151 Oceanography Teaching Bldg.
University of Washington
Seattle, WA 98195

Library
R.S.M.A.S.
University of Miami
4600 Rickenbacker Causeway
Miami, FL 33149

Maury Oceanographic Library
Naval Oceanographic Office
Stennis Space Center
NSTL, MS 39522-5001

Library
Institute of Ocean Sciences
P.O. Box 6000
Sidney, B.C. V8L 4B2
CANADA

Library
Institute of Oceanographic Sciences
Deacon Laboratory
Wormley, Godalming
Surrey GU8 5UB
UNITED KINGDOM

The Librarian
CSIRO Marine Laboratories
G.P.O. Box 1538
Hobart, Tasmania
AUSTRALIA 7001

Library
Proudman Oceanographic Laboratory
Bidston Observatory
Birkenhead
Merseyside L43 7 RA
UNITED KINGDOM

IFREMER
Centre de Brest
Service Documentation - Publications
BP 70 29280 PLOUZANE
FRANCE

50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO. WHOI-93-49	2.	3. Recipient's Accession No.

4. Title and Subtitle Long Time Series Measurements in the Coastal Ocean: A Workshop	5. Report Date November 1993
	6.
7. Author(s) C.L. Vincent, T.C. Royer and K.H. Brink	8. Performing Organization Rept. No. WHOI-93-49
9. Performing Organization Name and Address Woods Hole Oceanographic Institution Woods Hole, Massachusetts 02543	10. Project/Task/Work Unit No.
	11. Contract(C) or Grant(G) No. (C) OCE92-24824 (G)
12. Sponsoring Organization Name and Address National Science Foundation 4201 Wilson Boulevard Arlington, VA 22230	13. Type of Report & Period Covered Technical Report
	14.

15. Supplementary Notes

This report should be cited as: Woods Hole Oceanog. Inst. Tech. Rept., WHOI-93-49.

16. Abstract (Limit: 200 words)

Existing long time series efforts can be readily augmented by addition of existing sensors, enhancing their scope and impact. Significant benefits would result from multidisciplinary measurements to document long-term trends in physical as well as other variables. Standard observations as well as a diversity of approaches and measurements should comprise the suite of long-term measurements.

Sites for long-term observations should be selected to define processes, represent major and diverse oceanographic systems, and to document pristine as well as stressed systems. The initial rationale for sites and observed properties must be clearly defined to avoid monitoring for monitoring's sake. In the long term, three-dimensional zones ("corridors") of long time series measurements might be created.

Long time series measurements should be supplemented with process and modeling studies to ensure appropriate rationale and to provide a regional understanding for the site-specific observations. The Coastal Ocean Processes Program (CoOP) might provide some of these studies.

17. Document Analysis a. Descriptors

coastal ocean
long time series
observations

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
Approved for public release; distribution unlimited.	UNCLASSIFIED	106
	20. Security Class (This Page)	22. Price

(See ANSI-Z39.18) See Instructions on Reverse

OPTIONAL FORM 272 (4-77)
(Formerly NTIS-35)
Department of Commerce